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THOMAS CHROWDER CHAMBERLIN (1843-1928.)

By WALTER BARTKY.

On November 15, 1928, astronomy as well as other sciences was deprived of a great and valuable student—Thomas Chrowder Chamberlin. While geologists remember him by his world renowned work on the Wisconsin glacier deposits and educators by his teaching at Beloit College, Columbian University, and the University of Chicago, and his career as president of the University of Wisconsin, astronomers will always associate his name with his very important contributions to cosmogony.

In his *The Origin of the Earth* (1916) he has not only presented his planetesimal hypothesis of the origin of the sun's family of planets but has also beautifully demonstrated the steps and methods of his inquiry. A companion volume, *The Two Solar Families,* was his last published contribution to cosmogony and came off the press a few weeks before his death. In each of these two volumes he defends his venture into cosmogony, and shows how his efforts to interpret the glacial deposits of Wisconsin compelled him to take up this study. The following is taken verbatim from Professor Chamberlin's Introduction to *The Origin of the Earth* and very beautifully presents his reasons:

> If it shall seem strange to anyone that a student of the story of the rocks should turn aside from a field so solid and congenial to venture wantonly into the nebulous wilds of cosmogony, I can only plead in defense the urgent necessities of the scientific chase. It came to be clear that only by close pursuit along the trail that led into the cosmogonic fens and fogs was there any hope of overhauling the quarry that had awakened my instincts of pursuit—a pack of sophistical sprites that had long been wont to vex a pet climatic enigma on whose solution I had set fond hopes. It may be some little further extenuation of my temerity to plead that, at the outset, the trail was picked and the chase begun almost as far away as possible from the pass that led into the bogs and mists, and that at the start the trail was as cold as a glacier.

It was a very bold and dangerous step for a geologist to enter into fields of research that were previously the exclusive province of the mathematical astronomer. Lacking the ability to juggle mathematical symbols would he be competent to judge and criticize existing theories in cosmogony? The answer to this question was given as early as 1899 in Professor Chamberlin's discussion of the Helmoltzian hypothesis:

> Without questioning its correctness, is it safe to assume that the Helmholtzian hypothesis of the heat of the sun is a complete theory? Is present knowledge relative to the behavior of matter under such extraordinary conditions as obtain in the interior of the sun sufficiently exhaustive to warrant the assertion that no unrecognized sources of heat reside there? What the internal constitution of the atoms may be is as yet an open question. It is not improbable that they are complex organizations, and the seats of enormous energies . . . The Helmoltzian theory takes no cognizance of latent and occluded energies of an atomic or ultra-atomic nature. . . . Are we quite sure we have yet probed the bottom of the sources of energy and are able to measure even roughly its sum total? (On Lord Kelvin's Address on the Age of the Earth as an Abode Fitted for Life, T. C. Chamberlin, *Science*, Vol. IX, June 30, and Vol. X, July 7, 1899.)

How correct these statements have been shown to be in the last thirty years! Even to this day astronomers can read this quotation with enormous profit.

Not stopping to question only the adequacy of the Helmoltzian theory, Dr. Chamberlin boldly attacked the Laplacian hypothesis. Conclusions of a geological nature which followed from the theory of Laplace he showed to be at variance with the testimony of the rocks. Fortunately in this inquiry he was joined by Dr. Moulton who took the leadership in testing the Laplacian hypothesis by means of the laws of dynamics. These tests disclosed many more glaring discrepancies.

Not following the example of a vast multitude of critics, Dr. Chamberlin did not stop with destructive criticism. His main service to cosmogony was constructive. The same points that had been used in his arguments against inherited theories of planetary origin he employed as guides and as criteria to be met in the construction of a tenable interpretation. In this work as in all of his other work he made effective use of the method of multiple hypotheses. Every available hypothesis, even his own, was held tentatively and subjected to these criteria. Ignoring the hypothesis of a special creation he sought to explain the earth as an astronomical phenomenon. In the dynamical consequence of the close approach of another star to our sun he found a possible explanation. With the mathematical and philosophical aid of a master in celestial mechanics, Dr. Moulton, he was able to trace out the results of this approach. Eventually their research led to the development of the planetesimal hypothesis of the origin of the sun's family of planets. Not only was it found that this hypothesis accounted for the uniformities of the solar system quite as well as did the theory of Laplace, and that it avoided many of the difficulties encountered by that and older hypotheses, but it furnished a real foundation for the geologists which has proven to be in harmony with the evidences of their own science.

Dr. Chamberlin did not terminate his investigations of the consequences of the planetesimal hypothesis with the publication of his little

volume, *The Origin of the Earth.* We find him even after his retirement from the University of Chicago in 1919 at the age of seventy-six still continuing his study of cosmogony. That he still retained up to his death the ability to present and solve problems in cosmogony on a par with those attacked in his earlier works is evident in his last contribution to cosmogony—*The Two Solar Families or The Sun's Children.* In this book he gives the story of the planetary family and the cometary family, tracing the parentages of our planet and its kin as well as its wayward relatives, the comets, back to their stellar parentage.

In his later researches Dr. Chamberlin considered in greater detail the growth of the planets. Beginning with masses of sun-substance shot forth under the stimulus of the passing star he was able to trace the growth of the planets as the planetesimals gathered into the core. He concluded that the axes of rotation of the planetary missiles must have originally been placed near their planes of revolution and he followed the axial creep to their present directions. In his *The Two Solar Families* by introducing a sub-hypothesis he was able to describe the way in which the planetary missiles were shot from the sun.

> The following sub-hypothesis of the joint action of the passing star and the sun in propelling from the latter the planetary bolts which were later to grow into the planetary system, is offered merely as the most promising of the group of such hypotheses still entertained as possibly tenable. It is held with confidence that some combination of this order gave rise to the planets. . . .
>
> The passing star is assumed to have belonged to one of the more numerous classes and to have been somewhat less in mass than the sun. . . . To accord with the observed natural division of the planets into two groups, an outer one of four large low-density planets and an inner one of four small high-density planets, it is assumed that the large outer planets arose from projectiles shot toward the star and that the small inner planets arose from projectiles shot in the opposite direction from the opposite side of the sun. This accords well also with the break between these groups. These two groups of four bolts each are supposed to represent the systematic response of the sun to the differential attraction of the star as it passed obliquely over the two specially eruptive belts of the sun on either side of its equator. It is assumed that there were two shots toward and two shots from the star in crossing each belt, making, in all, four great missiles sent far out past the star in its rear and four smaller missiles shot shorter distances from the opposite belts on the far side of the sun. We thus postulate only four main double shots.
>
> The planetoids are supposed to have arisen from small irregular projections stimulated on the far side of the sun by the passing star before it reached the specially eruptive equatorial belts. . . . Counterpart eruptions of this irregular type on the side toward the star may possibly be represented by undiscovered bodies beyond Neptune, of which there are some signs.

> The planetary bolts as projected and propelled from the sun are held to have been far less unequal than the planets that grew from them. . . . The four outer projectiles shot toward the star may be likened to the great shells of heavy ordnance; the four inner ones shot away from the opposite side of the sun, to solid shot from smaller ordnance; and the planetoids, to bird-shot from a shot-gun.

It might be claimed that the introduction of sub-hypotheses would detract from the simplicity of the original hypothesis. It might be believed that the wonderful success of the original hypothesis had encouraged Professor Chamberlin to venture too far into the dangerous fields of speculation. But we might ask—should a scientist stop because one of his hypotheses was successful? In Dr. Chamberlin's last volume he has bravely put before the astronomer many of his last naturalistic ideas on cosmogony. In presenting these speculations he does not ask the astronomer to accept, but tells him either to develop or discard them.

The science of astronomy owes much to Professor Chamberlin; and the followers of that science will unite with the students of those other fields to which Professor Chamberlin has contributed so generously—Education, Philosophy, Literature, and Geology—to revere his memory many years.

UNIVERSITY OF CHICAGO.

THE RELATION BETWEEN CORONA AND SUN-SPOTS.

By S. A. MITCHELL.

For many years it has been recognized by astronomers that there is an intimate connection between the form of the corona and the sun-spot period. At minimum of spots the corona shows the long equatorial extensions and the strong polar brushes. After the time of minimum of spots the corona departs from these typical features, and at maximum of spots the corona is nearly circular in contour, in shape resembling a gigantic dahlia.

Ranyard in the "Eclipse Volume" of Memoirs[1] of the Royal Astronomical Society was the first to point out the connection between sun-spots and the shape of the corona. Hansky,[2] however, when more information was available, made the connection much more certain by publishing a series of reproductions of the corona from photographs and drawings arranged according to the sun-spot cycle. Five years later it was pointed out by Naegamvala[3] that the shape of the corona seemed to have a more intimate connection with the relative sun-spot numbers of Wolf than it had with the phase in the sun-spot curve at the time of the eclipse.

[1] *Mem. R. A. S.*, **41**, 496, 1879, and also **46**, 238, 1881.
[2] *Bull. Acad. Imperial, St. Petersburg*, V, **6**, 251, 1897.
[3] *Publ. Observatory Poona*, Vol. 1, 1902.

Apparently astronomers have been satisfied with accepting as a proven fact that there does exist some kind of intimate relation between the corona and sun-spots, but no detailed investigations have been made in recent years regarding the exact nature of the dependence. The trouble has been, as was pointed out by Campbell following the eclipse of 1922, that while in recent times eclipses had taken place at or near maximum of spots and also on the descending branch of the sun-spot curve, there had been only one eclipse since 1893 observed close to the time of minimum of spots but on the ascending branch, with sun-spots on the increase. This was the eclipse of 1914 whose observations were greatly interfered with by the beginning of the Great War. Since the eclipse of 1922, the years 1923, 1925, 1926, and 1927 have brought total eclipses, the first two of these falling shortly after minimum of spots which took place at 1923.6.

A very small percentage of astronomers have had the opportunity of witnessing a single total eclipse of the sun even though maybe in the capacity of a casual observer. For information regarding the shape of the corona most astronomers must, therefore, rely on reproductions from a printed page. Furthermore, these prints show the corona only as it is projected on the celestial sphere, in space of two rather than in that of three dimensions. Of course it might reasonably be urged that the form of the corona is far too complicated to be subjected to exact analysis. This is certainly true at maximum of spots when the great activity of the sun causes coronal streamers to shoot out at many angles.

As is only too well known, no photograph can represent the complete details of the corona. If a short exposure is made to secure the details of the inner corona, then the fainter extensions do not appear. If a longer exposure is made to secure the faint outlying portions, then the inner corona is hopelessly lost through overexposure. Even the original negative, unless of short exposure, shows little of the detail well visible to the eye. As soon as a photographic print is made on paper still more of the details are lost, while a half-tone reproduction, even if printed on glazed paper, has obliterated so very much even of the details shown on the original negative that the eclipse astronomer groans with despair in that the half-tone has made such an inadequate reproduction of the photograph of which he was so proud.

In spite of all these lamentable drawbacks, the reproductions do still retain some of their individual characteristics, at least they show that the intensity of the corona falls off very rapidly from the edge of the sun outwards. To H. Ludendorff[4] it appeared, that even in printed reproductions lines of equal intensity in the light of the corona could readily be drawn about the dark moon as center, and from these lines of equal intensity a close approximation to the shape of the corona could be obtained. In consequence, simple measurements carried out by him have given information of great value. Ludendorff was enabled to

[4] *Sitz. der Preuss. Akad. d. Wiss. Phys-Math Klasse*, **16**, 1928.

make measurements of reproductions from no less than thirteen eclipses taking place between the years 1893 and 1927. He superposed on each reproduction of the corona that he was able to find in the published literature, a thin piece of semi-transparent paper. On each separate sheet of paper he traced lines of equal intensity running around the corona, and also at the same time he marked the edge of the moon. Photographs were better for his purpose than reproductions. He found that the tracing paper obliterated still more of the individual peculiarities of the corona that had survived the processes of reproduction. The strange result, however, was achieved that the loss of the details in the corona may have even increased the accuracy of drawing lines of equal intensity in the coronal light. In some cases, the equal intensity lines were already available in the original sources, especially in the corona of 1905 from the investigations of Graff and in that of 1914 by Bergstrand. Comparisons made by Ludendorff of his own tracings with the results of Graff and Bergstrand, obtained by more accurate methods, showed no systematic differences between the crude and refined methods.

Having obtained the tracings of the lines of equal intensity in the manner just described, Ludendorff measured by means of dividers and scale the intercepts from the center of the sun in eight directions separated at angles of 22°.5 with respect to the directions of the sun's axis. For most of the reproductions it was difficult to be always sure which was N or S on the photograph and even more uncertain in regard to the E and W limbs. The details of the corona, particularly those around the sun's axis permitted the orientation of the photographs with all the accuracy necessary. No confusion resulted from lack of knowledge regarding N and S, and E and W directions, as the measures made in the solar equator and at 22°.5 on either side were compared with similar measures made around the sun's axis. With the edge of the moon appearing on each of the tracings of the corona it was a simple matter to reduce all measures to the radius of the moon as unity.

The shape of the corona approximates that of an ellipse, and hence comparisons of the polar and equatorial diameters will give the means of determining the flattening or ellipticity. Ludendorff was able to make 154 of these comparisons, no eclipse being utilized unless a minimum number of six were available. For this reason the eclipse of 1922 was not included.

For each eclipse, the measured flattening of the coronal ellipse of equal light intensities determined from the individual reproductions was plotted as ordinate against the distance from the center of the sun as abscissa. At angular distance less than one radius from the edge of the sun (or two radii from the sun's center) the flattening derived from each reproduction can be expressed by the simple linear relation,

$$e = a + bd$$

where e is the flattening of the ellipse and d is the distance from the

sun's edge measured in terms of the sun's radius as unity. The value a in this formula represents the ellipticity of the corona near the edge of the sun, while $a + b$ is the ellipticity at a distance of one radius from the sun's limb. From the measures, the constants a and b are found for each eclipse by the method of least squares. Following a and b in Table I are the probable errors, while in the last column are given the numbers of reproductions measured.

TABLE I.

Eclipse	a		b		n
1893 April 16	+0.031	± .009	−0.028	± .012	10
1896 August 8	0.028	.011	+0.226	.025	9
1898 January 21	0.057	.009	+0.117	.015	15
1900 May 28	0.024	.010	+0.284	.021	15
1901 May 18	0.027	.012	+0.245	.028	10
1905 August 30	0.012	.005	−0.002	.008	27
1908 January 3	0.058	.012	+0.017	.023	8
1914 August 21	0.045	.006	+0.153	.012	13
1918 June 8	0.129	.005	+0.103	.024	10
1923 September 10	0.059	.010	+0.176	.019	13
1925 January 24	0.045	.011	+0.094	.023	11
1926 January 14	0.058	.021	+0.011	.023	7
1927 June 29	0.041	.012	−0.005	.022	6

For the coronas near sun-spot maximum, it was found that b approximates to zero, or, in other words, the corona is nearly circular. The values of a for the separate eclipses have only a small range between maximum and minimum type of coronas. (The values for the 1918 eclipse are unusually large. For reasons to be shown later this was an exceptional eclipse.) Hence, near the surface of the sun all coronas show a greater extension at the equator than along the sun's axis. Near minimum of spots, however, the corona becomes more and more flattened at the poles or elongated along the sun's equator at greater and greater distances from the sun's edge. At distances from the sun's edge greater than one radius, it was found that the linear relation connecting a and b no longer held.

The difference between maximum type of corona and that of minimum is reflected by the values of the quantity b in the above table which increases from zero with elapse of time after sun-spot maximum is past.

With these measured values giving the ellipticity of the corona, the next step was to find a correlation with the phase F in the eleven-year sun-spot period. Let M_1 and M_2 be the times of two successive maxima of spots, and m the intervening time of sun-spot minimum. If the time of the total eclipse is T, and this occurs at the time of decreasing sun-spots, that is, between M_1 and m, then

$$F = \frac{T - m}{m - M_1}$$

In this case F is negative. If, however, T is on the ascending branch of the curve, between m and M_2, F is positive and is represented by

$$F = \frac{T - m}{M_2 - m}$$

In addition to the phase in the sun-spot cycle just defined in numerical terms, Wolf's relative sun-spot numbers may be utilized to determine the condition of the spot activity. The Wolf relative number for the day of the eclipse might be used for investigating the connection with the shape of the corona. It is probable that it is not the actual spots on the sun on the day in question that directly affect the coronal features but rather the condition of the general activity of the sun. This activity would be more adequately reflected by taking average values of the spot numbers both before and after the day of the total eclipse.

As the sun's synodic period is twenty-seven days, Ludendorff took a mean of the values of the spot numbers for the day of each eclipse and for thirteen days before and thirteen days after the eclipse.

The exact relation between the form of the corona and the sun-spot curve did not stand out clearly until his measures from the thirteen eclipses were divided into separate groups as given in the following table.

TABLE II.

Sun-Spot Eclipse	No.	*a*	*b*	Phase	Sun-Spot No.	*a*	*b*	Phase	Eclipse
					88	+0.03	−0.03	+0.82	1893.3
					77	+0.06	+0.01	+0.55	1926.0
1918.4	69	[+0.13]	[+0.10]	−0.87					
					67	+0.04	0.00	+0.89	1927.5
					59	+0.01	0.00	+0.85	1905.7
1908.0	45	+0.06	+0.02	−0.78					
1898.1	27	+0.06	+0.12	−0.47					
1896.6	22	+0.03	+0.23	−0.67					
1901.4	11	+0.04	+0.26	−0.04	11	+0.06	+0.18	+0.02	1923.7
1900.4	9	+0.03	+0.29	−0.17	9	+0.05	+0.16	+0.25	1914.6
					8	+0.05	+0.10	+0.34	1925.1

On the left side of the table are the eclipses which have taken place between maximum and minimum of spots, with spots decreasing in number, while on the right hand are the eclipses occurring after minimum of spots on the ascending branch of the sun-spot curve. One should read the table *down* on the left side, from maximum and then *up* on the right side after minimum is past, with the spots increasing in number.

The material of the table is arranged according to decreasing values of the sun-spot numbers on both sides of the table. From the values of both *a* and *b* in the table, it is again seen that the corona of 1918 was very exceptional. In drawing general conclusions it is for the present left out of consideration. As already stated, the value of *a* is nearly constant for all eclipses with the value +0.04 and the probable error ±0.011.

The shape of the corona depends on the value of *b*, which is nearly

zero, or the corona nearly circular in contour at maximum of spots. The probable error in the determination of b is ± 0.020. After maximum of spots the corona loses its circular shape and the equatorial extensions become greater and polar brushes shorter.

The dates of minimum of spots took place around 1901.7, 1913.6, and 1923.6. The curious thing shown from the table is that the quantity b has larger values *before* minimum of spots than *after* the minimum is past. Four eclipses, those of 1896, 1898, 1900, and 1901, took place at an average of 2.6 years *before* the sun-spot minimum of 1901.7, and the quantity b had a mean value $+0.22$. The eclipse of 1914, and those of 1923 and 1925 occurred on the average only 1.0 years *after* the minima of 1913.6 or 1923.6 and the value of b was $+0.15$, or fifty per cent less than the value 2.6 years before minimum. In fact, the eclipse of 1923 took place within about a month *after* the time of minimum of spots and yet the value of b amounting to $+0.18$ was of the same size as the average of the two eclipses of 1896 and 1898 which happened more than four years before the date of minimum of spots.

It is fortunate that the eclipses of 1923 and 1925 gave measures of the shape of the corona at that part of the sun-spot curve where the information before had been very weak. Although the values derived from four eclipses before minimum and three eclipses after may be subject to some slight revision, it is apparent that the great equatorial extensions of the corona that are associated always with minimum of spots are not necessarily found exactly at the time of few spots. Although the information is not positive, it does seem probable that the maximum equatorial extensions of the corona and the shortest polar brushes may take place one to two years *before* the time of minimum of spots. The eclipse of 1896, five years before spot minimum showed as many of those characteristics that we have been in the habit of associating with the typical minimum corona as did the corona of 1923 falling within a month *after* the minimum of spots was past.

Unquestionably, immediately after the time of minimum, or more probably a year or more before minimum, the new cycle of spots already appearing in high northern and southern latitudes affects the sun with the result that the awakened solar activity manifests itself by pronounced changes in the coronal radiation. As a consequence of the increased intensity of radiation in the corona, the following effects are shown: (1) The emission lines of the coronal spectrum are intensified. The line in the red at $\lambda 6374$ was discovered at the eclipse of 1914. At the eclipse of 1925 this line was again of such strength that it was shown on brief exposures made with high dispersion on the flash spectrum. (2) The medium level lines in the chromosphere reach greater heights, and (3) there are decided changes in the shape of the corona, the polar brushes becoming longer and the equatorial extensions shorter.

The values of b in Table II show that the shape of the corona is probably more intimately connected with the Wolf numbers than it is

$$F = \frac{T - m}{M_2 - m}$$

In addition to the phase in the sun-spot cycle just defined in numerical terms, Wolf's relative sun-spot numbers may be utilized to determine the condition of the spot activity. The Wolf relative number for the day of the eclipse might be used for investigating the connection with the shape of the corona. It is probable that it is not the actual spots on the sun on the day in question that directly affect the coronal features but rather the condition of the general activity of the sun. This activity would be more adequately reflected by taking average values of the spot numbers both before and after the day of the total eclipse.

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The values of b in Table II show that the shape of the corona is probably more intimately connected with the Wolf numbers than it is

with the phase in the sun-spot cycle. The information on this point, however, is far from being conclusive, for by referring to the Table it will be seen that the whole matter really rests on the relative positions of the eclipses of 1896 and 1898. The eclipse of 1918 adds some information to the subject. Many different observers have noted that the shape of the corona of the eclipse was very exceptional in that it had the form associated with maximum of spots though at the same time it had also the strong polar brushes belonging to the minimum type of corona. Pettit and Miss Steele[5] even state that the western side of the corona was of the maximum type while the eastern side on the contrary had more nearly the shape associated with minimum spots. In investigating this eclipse in detail, Ludendorff finds that the Wolf numbers show that the sun had many spot groups on its surface about a week before the eclipse of that year of June 8. The difference in activity of the sun before and after the eclipse was very striking and these changes of activity are found by Ludendorff to show themselves in pronounced changes in the coronal radiation. Consequently, this exceptional eclipse of 1918 furnishes additional proof of the belief that the form of the corona is intimately associated with the spots that are actually on the sun at the time of the eclipse. This statement should not be construed to mean that the spots themselves are the direct cause of changes in the radiation of the corona. Rather the underlying cause is to be found in the activity of the sun itself which is bound up with the eleven-year period. The reawakening activity of the sun near the time of minimum of spots shows itself in three different portions of the sun: (1) In the photosphere, by its increased radiation causing spots to appear. (2) In the chromosphere, the increased radiation carries the elements of medium height to greater average elevations. (3) In the corona, the increased radiation causes an increase in strength of the emission lines of coronium and also makes the corona lose the shape associated with minimum of spots, of long equatorial extensions and short polar brushes.

All of these observations have an important bearing on theories of the corona. The conclusions on this subject will soon appear in the memoir on "Eclipses of the Sun" in Volume IV of the *Handbuch der Astrophysik*.

[5] Popular Astronomy, **26**, 479, 1918.

PISCES

Two Fishes in the sky-deeps swim,
Both elongated but quite dim
Which seems to be a paradox:
Because they lead the Zodiac,
Are famous in the almanac,
And own the vernal equinox.

1490 Stuart St., Denver, Colorado. Lilian White Spencer.

THE ASTRONOMICAL FRATERNITY OF THE WORLD.

By DAVID B. PICKERING.

Part VI.

Few of the peoples of our race can boast a national life of over a thousand years. Of these few, none are more justifiably proud of their continuity as a nation than the Magyars, for none have struggled more desperately against insuperable odds.

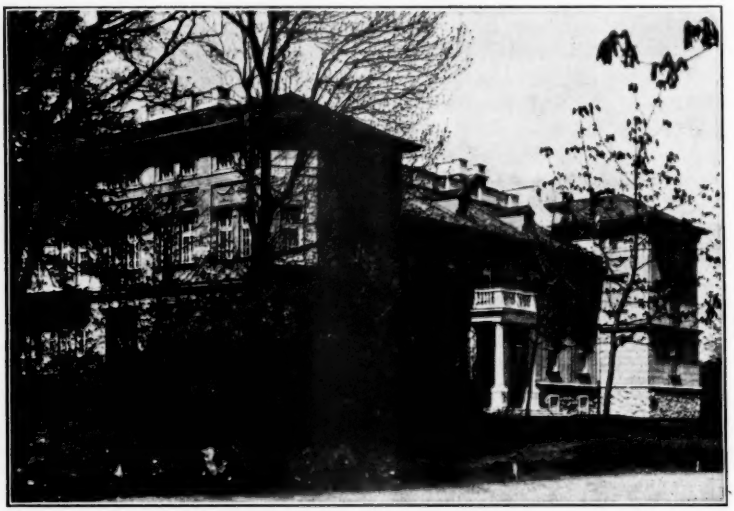
Since those first barbaric, slavic tribes emerged from the wilderness in that dim long ago, and were forced by influences of civilization into a crude cohesive entity, the Hungary that was to be has ever been a foot-ball of ungentle fate. Lacking every advantage of geographical prestige or political stability, buffeted and bruised between the Occident and Orient, Hungary seems ever to stand with her back to the wall, with set teeth and clenched fists, maintaining her integrity through the inherent character of her people as well as by the force of her great leaders.

One recalls a scene in a beautiful square of Budapest, rich in sculptured monuments. A huge gray-haired, square-shouldered man, his arm about one of the score of diminutive lads that are grouped around him, stands facing a statue that pours out in stone its age-old story of some early heroic deed of patriotism in the life of their nation. The venerable teacher is feeding the flames of racial and national pride in the youthful breasts of his pupils.

From the Pesth side of the broad, dark Danube, spanned here by its four great bridges, one looks across to the heights of ancient O-Buda, upon one of which stands that vast and beautiful palace built by Maria Theresa, now awaiting a king, yet to be chosen. Pesth itself, the newer and more rapidly growing quarter, with its surprisingly modern structures, stretches far back from the east bank of the river. The uniqueness and beauty, the majesty and enterprise of this dual municipality both astound and thrill the traveler of continental Europe, who, for the first time, enters the capital of Hungary. The delicacy of its music, the beauty of its art, the strength and grace of its architecture, above all the smiling bravery of its devoted and patriotic people, recall days of delight that one hopes to live again other than in memory.

"Csillagvizsgáló Intezet" was the scramble of letters in the local telephone book that one had to translate into "Astrophysical Observatory" before telephoning for an appointment to see that interesting institution. Five miles from the Hotel Hungaria in Pesth, high on the hills back of O-Buda, there is being developed a national institution for astronomical research of which the people of Hungary may well be proud. The Treaty of Versailles took from Hungary two-thirds of her territory

and her people. When the red dust of war began to settle she saw her erstwhile national observatory at Ogyalla, standing far beyond her borders in Czechoslovakia. Not a single instrument, not a book from the library, was left in the possession of the new Hungarian state. Crushed, maimed, humiliated, the pride of her people reasserted itself for the hundredth time. Despite their suffering and poverty, with their backs again to the wall, they demanded a national observatory for Hungary. The city gave the land, 600 feet square at 1500 feet above sea-level, and built the road to connect it with the nearest highway. It also provided for the largest of the several domes. The state gave the other edifices and the instruments.



Main Building of the Astrophysical Observatory of Budapest.

Traveling through hilly, wooded country, along the ever winding road, upward and outward beyond the outskirts of the city, one arrives at last before the portal of the main building of the Observatory. This edifice, of beautiful proportions and details, is separated from the new street by wide smooth lawns. The character displayed in its 150-foot façade bespeaks the experience and taste of its modern architect. At the time of my visit, in April, 1927, the plaster in parts of the finished structure was barely dry and only the necessary executive and living quarters were fully furnished and in use.

Dr. Charles Lassovzsky, a slender young man of about thirty years of age, assistant to Dr. Tass the Director, was waiting to greet me and aid in the adjustment of pingos and fillers sufficient to satisfy the taxi driver. Dr. Lassovzsky had obtained his degree in 1920 and in 1923

was engaged by the Observatory. The Rockefeller Foundation sent him to America for the year of 1925, five months of which he spent at the Harvard College Observatory. He led me through expansive halls and up wide stairways to the Director's room on the second floor. Dr. Tass was most cordial in his greeting. The Director is a ruddy-complexioned, square-faced man of about fifty, stocky and of medium height. His heavy mustache crowns a constant smile and in his mouth is always one of those good little Hungarian cigars, a box of which he at once placed before me. The room was a cheery one, with massive desks and center-table, and well lighted, as all other quarters were found to be, since the building is but two rooms deep, these being divided by a broad central hall that parallels its front.

Dr. Tass spoke no English, but with Dr. Lassovzsky to act as interpreter and the occasional use of German, with which everyone seems familiar, we had no difficulty in conversing. They proceeded to tell of their misfortune in losing so much to Ogyalla, which Observatory, up to that time, had not again been put into service.

They explained the friendship of their people for the Germans and spoke of their relief at being freed from the ties of the dual monarchy. They informed me that this new institution was begun late in 1921 and that it was expected to be finished in 1932. The Director presented me with a copy, in German text, of the work of their first three years. There were but three members of the staff actively engaged at that time, but at the University of Berlin, were two young men being specially trained for the work. Dr. Lassovzsky later impressed upon me the great organizing power of the Director; indeed, as the moving force of this project, developed under existing conditions, this was very obvious. He told of the Director's efforts to keep the Secretary of Agriculture informed of meteorological conditions and of his aim to coöperate in every way with the government whose aid in this important enterprise had been so generously given and so desperately needed. Knowing the work of Dr. Tass in the field of Variables, it was natural to inquire regarding the activities of local amateurs along that line. This elicited the information that, although there was an amateur astronomical association in Budapest of 1000 members, each of whom subscribed to a year book and received the official almanac, none among them was known to do any observing. Here, as was later found to be the case in all Germanic countries, the potential powers of the amateurs for helpfulness had not been awakened. The lovers of stars among the lay-men remained unorganized; their aid unsolicited.

Leaving the Director's office at length, we proceeded to inspect this handsome new edifice, which faces the east and overlooks the city far below. At the southern end the wide second floor hall opened into a splendid auditorium, 25 by 66 feet, finely adapted for lecture or demonstration purposes. At the northern end are living quarters for members of the staff, each centrally heated, with private bath, good

light and ventilation. These have their outlook toward the front while across the hall and facing the west are the dark-rooms with their red glass doors, and the studios, all well equipped for modern photographic work. On the ground floor, in a room below the auditorium, were stored many of the instruments whose housings were at that time under construction. Here were the 10, 8, 7, and 6-inch telescopes, as well as many instruments of other character. Among the latter was a beautifully mounted 4-inch Zöllner photometer as well as wedge photometers and various micrometers of great refinement and precision. Below the ground are extensive dynamo and battery rooms, all to be connected with the outside telescope houses and planned to furnish auxiliary power should the city service fail. Here too, are the rooms for radio equipment and the even temperature chambers for the clocks. Ascending to the topmost floor, we visited the library at the northern end of the building. All the space in its three large sections is well economized; shelving is built around the pillars and the low ceilings tend to make all volumes reachable. Few books adorned its shelves at that time, for like all else, they had gone to Ogyalla. From the library we stepped out upon the wide platform in the center of the roof and from its stone balustrade looked down upon the grounds in the rear. Not far back from the southern end of the building, stands the completed dome that was soon to house the 6-inch Cooke refractor. Farther off and to the left is that for the 8-inch Heyde, whose fine equatorial mounting we had seen below stairs. Directly in the rear of the main building was being erected a larger housing, as yet domeless, which will contain a splendid photo-visual reflector by Zeiss of 24 inches aperture. With this will be mounted a 12-inch refractor by Gustav Heyde of Dresden, who will also make the mounting for the large mirror. The dome will be constructed by Zeiss, who will also furnish the oculars for both instruments. The house was being planned for an elevating floor with a rise of 8½ feet and modern chair stands are to be provided for Newtonian observation, when the instrument is used in this manner. Dr. Tass, when we met last summer in Leiden, stated with pride that this fine instrument was then in service.

At the northern end of the grounds stands the transit house containing three instruments by Heyde which are used for the determination of time and the variation of longitude. Here also are sun glasses, photometers, and micrometers.

We later inspected these buildings at closer range and it was astounding to note the ease with which the smaller, hand-operated domes could be moved. The Director stated that the wind alone would at times turn that of the 8-inch. This dome rides on one-inch steel balls, each of which maintains its approximate position by spiral springs secured horizontally on either side of each ball. The shutters of all the domes, even the smallest, break vertically and slide apart.

The dome of the 6-inch telescope is attractively covered with those

miniature "fish-scale" shingles that one sees so often on the buildings of old German towns.

DR. TASS *(right)* AND DR. LASSOVZSKY OF THE OBSERVATORY OF BUDAPEST.

It was mid-day when we again repaired to the Director's office where Dr. Tass gave me notes of introduction to the directors of museums and art galleries in the city. Dr. Lassovzsky had sent for his swift little motor-car and after bidding adieu to the smiling Director, with cordial mutual felicitations, he conveyed me along wood-bordered roads to the highest point in the vicinity. Upon this height rises that gray stone monument, a veritable temple of love, erected by the people as a memorial of their affection for their late queen Elizabeth. Her devotion to the cause of Hungary will endear her memory to them forever. Thereafter, at an inn in the hills overlooking the city, came a luncheon of goulash, with more than a touch of the inevitable garlic, followed by bits of that delicious Hungarian pastry, so famed for the variety and flavor of its little cakes, that we demand it, even in America.

Leaving the auto at the inn, we boarded a nearby tram for the steep descent into O-Buda, and before long were applying for admission to one of the more imposing residences facing the broad boulevard that lines the west bank of the Danube. A trim maid ushered us up the broad, heavily carpeted stairway to the floor above, where, in a large,

richly furnished room whose deep windows gave upon the dark river, we were greeted by a very tall and very stately gentleman. His hair and pointed beard were white and there was a world of feeling in his deep-set eyes, whose soft glance from that fine old countenance bespoke both strength and gentleness. He it was whose influence and efforts had contributed so largely to make possible all that I had seen that morning. The Baron Bela Harkanyi, or as his card would read "Báró Harkányi Béla," seemed to personify the spirit of the Magyar. He seemed typical of those people who, fed with difficulties and constantly thwarted, had, nevertheless, achieved character and developed strength; who accepted the inevitableness of conflict and oppression as their heritage, but who faced their fate with leveled eyes and squared shoulders and counted it all as worth the cost of maintaining the national life of Hungary.

Baron Harkanyi was of the real aristocracy. At the close of the war he had taken a position in the local university as Assistant Professor in Astronomy and discussed with pride and animation the progress and prospects of the new observatory.

Later he told of those dark days in 1919 when the terror-ridden city was dominated by the Bolsheviki. He laid his finger upon a clean round hole in the plate glass of one of the front windows and told how nearly his life had been forfeit to one of the red snipers. He had been one of a group of the nobility, who for weeks had been herded together awaiting execution, their jailors impatient to have it over and done with. Day by day the order was stayed. The turn came and by the closest margin their lives were saved. Budapest, in the far east of Europe, could afford no reprisals. The Reds were packed into box-cars, which lumbered back into the Orient. In a short while this war-shocked, poverty-stricken people were crying loudly—for what? Not only for those things which make for physical rehabilitation, but also for improved institutions for art and science and the dissemination of knowledge, and for a new national astrophysical observatory.

Well may we uncover and sense humility before such pictures of pride, patriotism, and progress.

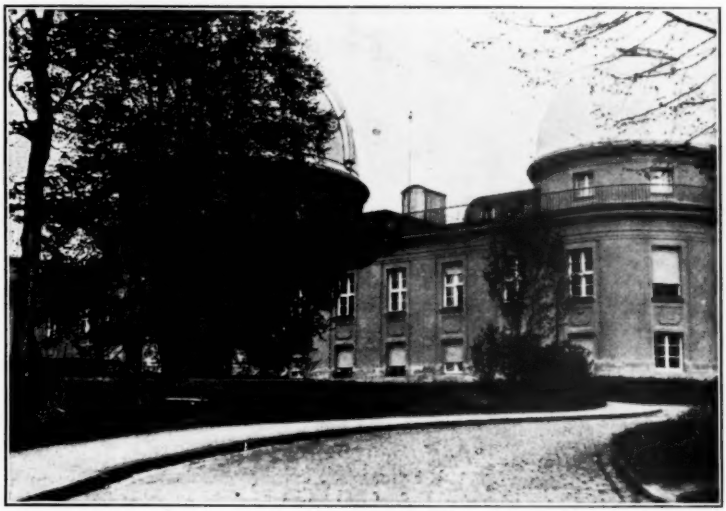
From our little table on the sidewalk café in front of the Hotel Hungaria, on the other side of the dark, swift Danube, Dr. Lassovzsky and I watched the light fade out of the sky behind that magnificent palace of past kings that stretched its imposing length on the hills of Buda. We had finished our coffee and cakes and our talk had been of his people, their hopes and aspirations, their art and science, their music, their intense racial integrity and, what I sensed so well, their charm.

So ended another of those days that tend to develop a finer understanding of distant friends and help so much to enrich our memories.

We made our second stop in Vienna on our way to Germany. It was election day and therefore Sunday—the first of May. Everywhere were the red flags and placards, symbols of the powerful socialist party. They

even decorated the locomotive of the train that was to carry us northward to Dresden where we had planned to sojourn for a few days, before proceeding to the metropolis of Central Europe.

Berlin is the world's fourth largest and its fastest growing city. Its population of over four millions has been acquired largely by physical expansion—by extending its wide borders and absorbing the suburbs. It has a rare fascination and a charm quite its own despite the fact that there is something in the character of its topography vaguely reminiscent of Paris, though its features are rather more restricted and shut in than are those of the play-ground of the world, with its expansive boulevards and magnificent distances. A few miles to the west of Ber-



Main Building of Neubabelsberg Observatory.
(Dome of 27-inch Zeiss Refractor at left.)

lin lies Charlottenburg whose three hundred thousand people have now been added to the population of the greater city. Somewhat farther are various waterways that extend toward the southwest and join to form a rather considerable lake known as the Havel, upon the shores of which, sixteen miles from Berlin, lies Potsdam. This city of palaces was the nursery of Prussian militarism. Here Frederick the Great, in 1745, erected that regal domicile which he called "Sans Souci." Over a hundred years later, upon the wooded heights above Potsdam, was built the great National Astrophysical Observatory. Not far from Potsdam, on the shores of the Griebnitzsee, a tributary to the Havel, lies the little residential town of Neubabelsberg. On the elevation above

its clustered villas, there has been constructed in recent years, the Observatory of the University of Berlin.

It was to visit this institution that we made the thirty minute train ride from Berlin, one fine May day, and after a short taxi ride from the suburban station, through clean, tree shaded streets, found ourselves before the quaintly pillared entrance gates of the Observatory. Past the caretaker's lodge and a trim power-house, a well-kept road wound upward into the grounds. At the door of the Director's residence, we were soon being greeted by a tall gentleman, above whose very bold mustache shone a pair of laughing eyes.

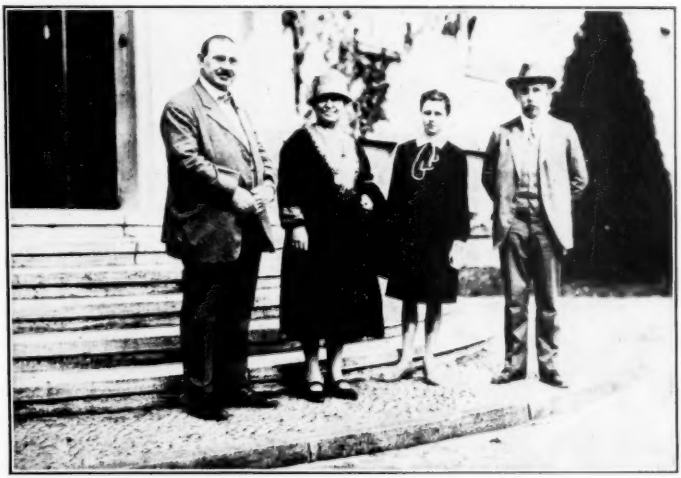
One soon realizes that in Professor Guthnick is to be found a fine combination of wisdom and good nature. His movements were quick and his perceptions alert and all his intercourse was mellowed by a broad affability. We were here again forced to open our little bag of poorly assorted German words and phrases, for Professor Guthnick spoke no English. Mrs. Guthnick, who soon joined us, spoke our language fairly well, however, and this made it easier for us to reach a plane of understanding. After a pleasant little visit the Director insisted upon acting as our cicerone during a tour of the buildings and grounds.

This very modern institution was founded in 1910. The property covers an area of about twenty-five acres and all of its buildings are of brick and stone combination. The great central edifice, supporting its three huge domes and with its beautiful façade slowly being encased in ivy growth, stood but a few yards from the Director's residence. Intervening trees, through which trailed very winding paths, hid this and the neighboring buildings from the city streets. Arriving at his office, the Director at once introduced us to Miss Gertie Rash, a diminutive young lady with a charming though rather shy manner. Miss Rash had joined the staff but two weeks before our visit, but having lived long in England with her English mother, was deputized at once to act as our interpreter. (Upon meeting Professor Guthnick at Leiden last summer, he informed us that Miss Rash had become so enamored of the science, that she had broken into the Fraternity by marrying one of the staff.)

As we began our inspection we were impressed by the newness and orderliness of the quarters and the air of quiet efficiency that everywhere prevailed. Under the great central dome, stood the 27-inch Zeiss refractor with its movable floor. Beneath another was the Zeiss triplet of 17, 15, and 13 inches, with its two short-focus cameras. This instrument was ordered before the war, and as originally planned, was to have larger apertures, but increased costs and relatively reduced funds necessitated the present sizes. Professor Guthnick explained that prior to the war, the generosity of the great Zeiss Company made possible the acquisition of very superior equipment by many observatories that could not otherwise have procured it. The crippling effect of the war,

however, made a continuance of this altruistic policy impossible and resulted in much consequent economic curtailment.

In separate buildings about the grounds were smaller instruments, the largest of which were two refractors of about 12 inches aperture each. From the roof of the main building one could obtain a good view of all the other domes. I noticed one in particular that towered upon a building seemingly more remote than the rest, and something in its appearance struck me as odd. The dome seemed rather pointed and bore an ornament upon its summit. The director laughingly explained that it adorned the home of a neighbor who became so impressed with the character of the nearby architecture that he constructed this superstructure to conform with those of the observatory.



Dr. Prager, Mrs. Pickering, Miss Rash, Professor Guthnick at Entrance to Neubabelsberg Observatory.

Upon leaving the main building to visit the beautiful 52-inch reflector, housed in its own well-equipped quarters at some little distance from the others, we saw two men atop a ladder, working at the shutter of one of the smaller domes. We were informed that an observer had spent the last night but one, working with the instrument there housed. The following night he prepared to continue, but was unable to open the shutter and had to abandon his program. Upon investigation, on the morning of our visit, it was found that in the single day between the two nights mentioned, birds had built a nest in the hollows of the shutter slides, in such a position as to block completely the operation of the shutters. This example of the rapid building of a domicile vied with stories of American speed construction. It baffled a scientist and

enforced a night's interruption of labor. It also added another to the many possible difficulties to be encountered by the harassed astronomer.

The great mirror is a masterpiece of Zeiss construction. Though ordered before the war, it was not finished until 1922. It can be operated, of course, both as Cassegranian or Newtonian, and the crisp newness of its mounting and dome make it a thing of beauty to contemplate.

In one room of the fine laboratory which forms an extension of this particular Observatory, we found Professor Prager. As we entered he rose from his seat before a fine Zeiss *blick* instrument—just where one would naturally have expected to find him,—and with a broad smile on his round good-natured face and that quick, short German bow, that seems actuated solely by the hips, welcomed us to his sanctum.

Professor Prager is a very large man, with rotund figure and is seemingly on the sunny side of forty. He is considered one of the leaders of Europe in the investigation of variable stars and was most enthusiastic and expressive regarding his especial work in this line. Upon the death of Professor Hartwig, Professor Prager took over the important task of compiling and publishing the annual catalog of variable stars, so long managed by the former. We sat before the *blick* and observed the two plates then in position. These, taken of the same field under identical conditions, but at different times, showed star discs down to the 13th magnitude.

It was startling to note the marked contrast in the intensity of the discs, caused by a difference of only one magnitude. While they may photograph stars of the 17th magnitude, this work is normally done with plates which show stars only to the 13th or 14th magnitude. On these, within the twelve months prior to our visit, Professor Prager had found thirty short-period variables of maximum brightness of 10th or 11th magnitude and having an average range of about one magnitude. Twenty of these stars had been discussed by him in the "Nachrichten." Here seemed just the opportunity for learning about the amateur variable star observers of Germany. There appeared to be something wrong with the fact that although the American Association of Variable Star Observers had active members in fifty-four countries of the world, it could claim not one German member. Knowing the studious and efficient processes of the Teutonic mind and method the A.A.V.S.O. had been keen to overcome this deficiency.

It came as rather a shock and a surprise to learn that in all Germany there was no association of active amateur astronomers. The story was the same as that we had already heard and were to hear again. The "seeing" in Germany was much deplored and it was not believed that the amateur, with restricted equipment, would have the patience and perseverance required to succeed in the visual observation of variable stars. They were, therefore, not encouraged to organize or even to undertake the work, and no effort was made to coöperate with them or

to provide a bureau for the discussion of their results. Professor Prager said that he knew of only two amateurs in his country actively engaged in the observation of Variables. One was Herr Beyer of Hamburg, producer of that splendid Beyer-Graff atlas, and the other Herr Leiner of Konstanz. It is gratifying to note that, through subsequent correspondence, both of these gentlemen, together with another, Herr Ahnert of Wittenburg-bei-Chemnitz, at the time of writing, not only are members of the A.A.V.S.O., but their reports of Variable observations, received during the preceding year, have done much to make a notable record for the American Association.

Professor Prager joined us in visiting the well equipped dark-rooms and fine library. In the latter we again found the low ceiling which seems to characterize modern library construction. It was here that we met some of the other members of the staff: Doctors Bottlinger and Pavel and he to whom the Director referred as "the German Tucker," Dr. Courvoisier. Like Dr. Bernheimer of Vienna, the latter gentleman received his training under that old master of Heidelberg, Professor Max Wolf. The phrase "One of Max Wolf's boys" has a vast significance to the Directors of all great astronomical observatories.

They came with us down the winding roadway to the street, speeding us on our way with the same cordiality with which they had greeted us, but there was this difference—we had come as strangers—and now—

Standing between the massive gate-posts, topped by their clusters of heavy stone flowers, Professor Guthnick directed us to the landing whence later the boat would take us through the beautiful Griebnitzsee and Havel to Potsdam. We found time before leaving to regale ourselves at a neat outdoor café near the water's edge.

As we sat at the little white table, we sensed the glow of the warm May sun and that of the new friendships the morning had brought us. The beer and cheese were delicious. All was right with the world.

ARIES

This Ram was once the golden fleece
That bore Nephele's babes from Greece.
He died to honor Zeus. Then, he
Shone brighter than the brightest star
In Jason's dream: who wandered far
To bring his pelt to Thessaly.

1490 Stuart St., Denver, Colorado. LILIAN WHITE SPENCER.

THE ORBIT OF SATURN.

By WILLIAM H. PICKERING.

The computed positions of this planet, based on Hill's theory, while never showing any large deviations from the positions as actually observed, have been constantly in error by small amounts, sometimes positive and sometimes negative, but rarely until lately exceeding 1″. In our investigations regarding planet *O* this deviation was most trying, since the accidental errors of position were often twice the size of the computed deviations due to the unknown planet, and we had to depend largely for the eccentricity of the orbit on the shape of this perturbation curve. As soon, therefore, as I had so modified the orbit of Uranus as to make the various observed deviations of the planet from it explicable, and any future deviations probably predictable, it seemed desirable to see what the same method of attack would do for the much more puzzling orbit of Saturn. The deviations of that planet from its theoretical orbit since 1900, as determined at Washington, are given in my paper on "The Next Planet Beyond Neptune," POPULAR ASTRONOMY, 1928, **36**, 158, and in the Reprint on p. 16. In a recent letter Captain Eichelberger informs me that a rediscussion of some of the Washington observations "in connection with recent personal equation work has enabled a slight improvement to be made in some of the corrections in Saturn's ephemeris." These revised results together with the corresponding measures made at Greenwich, and sent me from Harvard, are presented in Table I, where the successive columns give the mean dates of the observations, the corresponding heliocentric longitudes of Saturn, the deviation according to Greenwich, the same according to Washington, their mean value and average deviation. In the last column 0″.7 has been added to the last three mean values.

TABLE I.

THE THIRD PERTURBATION OF SATURN.*

Date	H. L.	Green.	Wash.	Mean	A. D.	Mean +0″.7
	°	″	″	″	″	
1906.7	342	+0.38	—0.32	+0.03	±0.35	
07.8	354	+1.08	+0.82	+0.95	±0.13	
08.8	6	+0.87	+0.65	+0.76	±0.11	
09.8	20	+1.04	+1.14	+1.09	±0.05	
10.8	33	+0.49	+1.12	+0.80	±0.32	
11.8	47	+1.15	....	+1.15	....	
12.9	61	+0.75	—0.30	+0.23	±0.52	+0.93
13.9	75	+0.19	—0.57	—0.19	±0.38	+0.51
15.0	89	+1.20	—0.71	+0.24	±0.96	+0.94

Everything went satisfactorily up to this point, but when it came to the later measures trouble began. As has been already explained the

*Replacing a portion of Table III of "The Next Planet Beyond Neptune," POPULAR ASTRONOMY, 1928, **36**, 158, and Reprint, page 16.

Greenwich measures were not sent to me at first, because the assistant at Harvard failed to comprehend the data. Later they were sent, O — C = —0ˢ.07, —0ˢ.09, —0ˢ.08, —0ˢ.13, —0ˢ.17, —0ˢ.10, —0ˢ.13, —0ˢ.15, —0ˢ.07, —0ˢ.16, reduced here to seconds of arc, and published. (POPULAR ASTRONOMY, 1928, **36**, 218, Table I, column 3, Reprint page 25.) Now the Astronomer Royal writes me that they do not coincide with his figures, which he sent me. They certainly do not. These latter are given in column 3 of the annexed Table II.

I trust and expect that Professor Shapley will find some reasonable explanation of the differences between them, but in the meantime we shall use the Greenwich figures. Incidentally it may be mentioned that these give very much smaller deviations from the Washington figures than those formerly published. The successive columns are arranged as in Table I. In the last column 1″.3 has been added to the mean values.

TABLE II.

THE THIRD PERTURBATION OF SATURN.*

Date	H. L. °	Green. ″	Wash. ″	Mean ″	A. D. ″	Mean +1″.3
1916.0	103	—0.69	—0.83	—0.76	±0.07	+0.5
17.1	117	—0.85	—0.86	—0.86	0.00	+0.4
18.1	131	—1.35	—1.32	—1.34	±0.02	0.0
19.1	144	—1.30	—1.07	—1.18	±0.12	+0.1
20.2	158	—1.99	—1.26	—1.62	±0.36	—0.3
21.2	171	—1.26	—1.62	—1.44	±0.18	—0.1
22.2	184	—1.94	—1.63	—1.78	±0.16	—0.5
23.3	197	—1.88	—1.47	—1.68	±0.20	—0.4
24.3	209	—1.90	—1.29	—1.60	±0.30	—0.3
25.3	221	—1.92	....	—1.92	....	—0.6
26.4	233	—2.17	....	—2.17	....	—0.9
27.4	244	—1.77	....	—1.77	....	—0.5

The explanation of the corrections given in these last columns is as follows. In 1911 Washington made material changes in its transit instrument, introducing what is called a reversing prism eyepiece. Owing to these changes no measurements were secured that year. The changes obviously gave more correct results than before, but as we see by the fourth column of Table I, averaging the three deviations before and those after the change, the planet apparently fell back 1″.5 in its orbit, while according to Greenwich its fall amounted to only 0″.1. Early in 1915 Greenwich also made changes in its transit instrument, introducing a new micrometer supplied with a travelling wire. While Washington in the three years preceding and following this change recorded a falling back of only 0″.5, according to Greenwich the fall amounted to 1″.7. The instrumental change at Washington, therefore, apparently caused the planet to drop 1″.4 behind its former position, while that at Greenwich caused a recession of 1″.2. The modern measures are of course the more correct, but for our purposes the effect of such instrumental

*Replacing Table I of "The Next Planet Beyond Neptune," POPULAR ASTRONOMY, 1928, **36**, 218, and Reprint, page 25.

changes must evidently be avoided. We have, therefore, added half the Washington correction to the means given in Table I, and the mean of the Washington and Greenwich corrections to those given in Table II.

In Table III the first three columns give the mean date of the recorded observations for each apparition of the planet since 1829, the heliocentric longitude of Saturn on that date, and the deviations in longitude from Hill's theory. These results are plotted in the upper curve of Figure 1, with the numbers in the second column as abscissas and those in the third as ordinates. The approximate dates are given

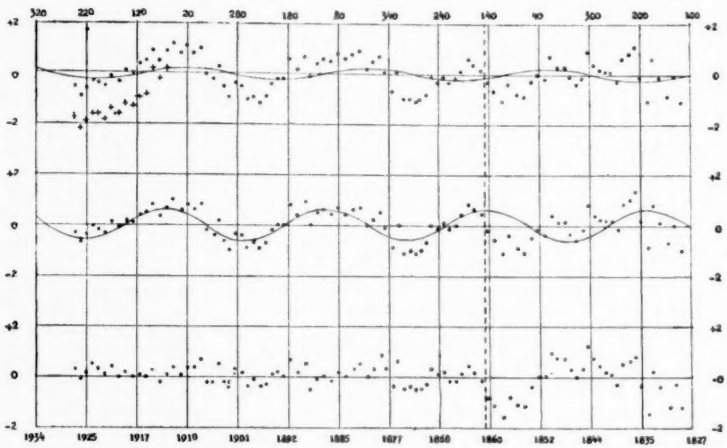


FIGURE 1.
THE PERTURBATIONS OF SATURN.

at the bottom of the figure. As far as the year 1900 the deviations are taken directly from "Hill's Astronomical Papers," *Amer. Ephem. VII,* and from his *Collected Mathematical Works IV,* 295. In the rest of the table the first three columns are taken from Table III, p. 158, of POPULAR ASTRONOMY, already referred to, and from Tables I and II of this paper, using the first, second, fifth, and last columns. The last three numbers in the fifth column of Table I, and all the numbers in the fifth column of Table II, are plotted as crosses, but these we shall not use in what follows, since we believe that they do not represent real retardations of the planet.

Another change that we propose to make is to eliminate all the earlier observations. These were necessary to Hill in order to get a long enough period on which to work. He was satisfied with a duration of 70 years. Many observations, and much better ones, have been secured since his day, and we have decided to accept those only which have been made since 1860.5, giving us 2.25 complete revolutions of the planet in 67 years. To improve Hill's theory requires more accurate observations

than were available to him. The earlier observations which he used deviate markedly from one year to the next as is shown by the upper curve. Those made since 1860, although they show large perturbations, run along much more continuously, and thus appear to be appreciably more accurate than those made earlier. Although the earlier observations are shown on all the curves, they are not considered in what follows, nor in the means taken. Although in a sense we may speak of these early observations as bad, yet we see that they never exceeded 1″.1. This is appreciably less than one-tenth of a second of time, which in turn is considerably less than the personal equation of most observers. In those days before modern accuracy was attained, personal and instrumental, I believe that we may fairly interpret deviations of this size, not necessarily as real displacements of the planet, but as due simply to accidental errors. In other words the scattering of the earlier deviations, and after 1840 the irregularity and sharp changes in their course, justify us, it is believed, in the elimination of all the observations prior to 1860.5.

TABLE III.

Date	H. L. °	Δ_1 ″	Corr.$_1$ ″	Δ_2 ″	Corr.$_2$ ″	Δ_3 ″
1829.1	122	—1.1	—0.05	—1.0	+0.18	—1.2
30.2	136	—0.1	— .11	0.0	+0.34	—0.3
31.2	149	—0.9	— .16	—0.7	+0.46	—1.2
32.2	162	—0.1	— .20	+0.1	+0.54	—0.4
33.3	176	+0.6	— .23	+0.8	+0.59	+0.2
34.3	188	—1.1	— .24	—0.9	+0.60	—1.5
35.3	201	—0.1	— .25	+0.2	+0.57	—0.4
36.4	213	+1.1	— .24	+1.3	+0.51	+0.8
37.4	224	+0.8	— .23	+1.0	+0.44	+0.6
38.4	236	+0.6	— .20	+0.8	+0.32	+0.5
39.4	247	—0.3	— .17	—0.1	+0.20	—0.3
40.5	259	+0.1	— .13	+0.2	+0.08	+0.1
41.5	270	+0.1	— .08	+0.2	—0.05	+0.2
42.6	282	+0.2	— .04	+0.2	—0.19	+0.4
43.6	293	+0.4	+ .02	+0.4	—0.30	+0.7
44.6	304	+0.9	+ .06	+0.8	—0.42	+1.2
45.6	316	—0.1	+ .11	—0.2	—0.51	+0.3
46.7	328	—0.4	+ .16	—0.6	—0.57	0.0
47.7	340	—0.1	+ .19	—0.3	—0.60	+0.3
48.7	352	+0.3	+ .22	+0.1	—0.59	+0.7
49.8	5	+0.3	+ .24	+0.1	—0.56	+0.7
50.8	18	+0.7	+ .25	+0.4	—0.50	+0.9
51.8	31	—0.2	+ .24	—0.4	—0.38	0.0
52.9	45	0.0	+ .22	—0.2	—0.23	0.0
53.9	58	—0.3	+ .20	—0.5	—0.08	—0.4
54.9	72	—0.9	+ .16	—1.1	+0.07	—1.2
56.0	87	—0.8	+ .10	—0.9	+0.24	—1.1
57.1	102	—0.4	+ .04	—0.4	+0.40	—0.8
58.1	115	—1.1	— .02	—1.1	+0.50	—1.6
59.1	130	—0.7	— .08	—0.6	+0.57	—1.2
60.1	143	—0.3	— .14	—0.2	+0.60	—0.8
61.2	157	+0.2	— .18	+0.4	+0.58	—0.2
62.3	171	+0.4	— .22	+0.6	+0.52	+0.1
63.3	183	+0.6	— .24	+0.8	+0.45	+0.4
64.3	196	+0.1	— .25	+0.4	+0.32	+0.1
65.3	208	—0.2	— .25	0.0	+0.20	—0.2
66.4	220	—0.3	— .24	—0.1	+0.05	—0.2

Date	H. L. °	Δ_1 "	Corr.$_1$ "	Δ_2 "	Corr.$_2$ "	Δ_3 "
67.4	231	−0.1	− .21	+0.1	−0.07	+0.2
68.4	243	−0.3	− .18	−0.1	−0.20	+0.1
69.4	254	−0.1	− .14	0.0	−0.32	+0.3
70.5	266	−0.8	− .10	−0.7	−0.44	−0.3
71.6	277	−1.0	− .06	−1.0	−0.52	−0.5
72.6	288	−1.1	− .01	−1.1	−0.57	−0.5
73.6	300	−1.0	+ .04	−1.0	−0.60	−0.4
74.6	312	−1.0	+ .10	−1.1	−0.59	−0.5
75.7	323	+0.1	+ .14	0.0	−0.57	+0.6
76.7	335	−0.7	+ .18	−0.9	−0.51	−0.4
77.8	348	+0.1	+ .21	−0.1	−0.41	+0.3
78.8	0	+0.7	+ .24	+0.5	−0.28	+0.8
79.8	13	+0.5	+ .25	+0.2	−0.13	+0.3
80.8	26	+0.2	+ .25	0.0	0.00	0.0
81.9	40	+0.9	+ .24	+0.7	+0.16	+0.5
82.9	53	+0.8	+ .21	+0.6	+0.31	+0.3
83.9	67	+0.6	+ .17	+0.4	+0.44	0.0
85.0	81	+0.8	+ .12	+0.7	+0.54	+0.2
86.0	95	+0.5	+ .06	+0.4	+0.58	−0.2
87.1	110	+0.6	.00	+0.6	+0.60	0.0
88.1	124	+0.4	− .06	+0.5	+0.56	−0.1
89.1	137	−0.1	− .12	0.0	+0.49	−0.5
90.2	151	+0.7	− .16	+0.9	+0.38	+0.5
91.2	164	+0.2	− .20	+0.4	+0.23	+0.2
92.3	177	+0.6	− .23	+0.8	+0.09	+0.7
93.3	190	−0.2	− .24	0.0	−0.05	0.0
94.3	202	−0.2	− .25	0.0	−0.18	+0.2
95.3	214	−0.4	− .24	−0.2	−0.32	+0.1
96.4	226	−0.9	− .22	−0.7	−0.44	−0.3
97.4	237	−1.1	− .20	−0.9	−0.52	−0.4
98.4	249	−0.9	− .16	−0.7	−0.57	−0.1
99.5	261	−1.0	− .12	−0.9	−0.60	−0.3
1900.5	272	−0.5	− .08	−0.4	−0.59	+0.2
1.5	284	−0.3	− .02	−0.3	−0.57	+0.3
2.6	296	−0.9	+ .02	−0.9	−0.50	−0.4
3.6	307	−0.5	+ .08	−0.6	−0.42	−0.2
4.6	318	+0.3	+ .12	+0.2	−0.30	+0.5
5.7	329	−0.2	+ .16	−0.4	−0.18	−0.2
6.7	342	0.0	+ .20	−0.2	−0.03	−0.2
7.8	354	+1.0	+ .22	+0.8	+0.09	+0.7
8.8	6	+0.8	+ .24	+0.6	+0.23	+0.4
9.8	20	+1.1	+ .25	+0.8	+0.38	+0.4
10.8	33	+0.8	+ .24	+0.6	+0.49	+0.1
11.8	47	+1.2	+ .22	+1.0	+0.56	+0.4
12.9	61	+0.9	+ .19	+0.7	+0.60	+0.1
13.9	75	+0.5	+ .14	+0.4	+0.58	−0.2
15.0	89	+0.9	+ .09	+0.8	+0.54	+0.3
16.0	103	+0.5	+ .03	+0.5	+0.45	0.0
17.1	117	+0.4	− .03	+0.4	+0.32	+0.1
18.1	131	0.0	− .09	+0.1	+0.15	0.0
19.1	144	+0.1	− .14	+0.2	+0.02	+0.2
20.2	158	−0.3	− .18	−0.1	−0.14	0.0
21.2	171	−0.1	− .22	+0.1	−0.29	+0.4
22.2	184	−0.5	− .24	−0.3	−0.42	+0.1
23.3	197	−0.4	− .25	−0.2	−0.52	+0.3
24.3	209	−0.3	− .24	−0.1	−0.57	+0.5
25.3	221	−0.6	− .24	−0.4	−0.60	+0.2
26.4	233	−0.9	− .21	−0.7	−0.59	−0.1
1927.4	244	−0.5	−0.18	−0.3	−0.57	+0.3
		±0".54		±0".47		±0".27

But even with these modifications it will be seen, as shown by the upper curve, that the theory of Saturn is still very unsatisfactory,—much more so as it appears than that of either of the other major planets. It had already been found that even the sinusoid method of treating the deviations could produce no great improvement in it. Sinusoids with amplitudes of 1″ or over were hopeless. An amplitude of 0″.5 did better, but one of 0″.25 was better still. With this method of treating the orbit a period of 360° is obligatory. For the remaining element of the sinusoid it was found that an ascending node in longitude 290° gave the best result. This curve is shown drawn upon the figure. The fourth column of the table gives the corresponding corrections, and the fifth the revised deviations, which are plotted as the second row of dots. This second row may be considered as due simply to a straightening out of the first sinusoid to coincide with the ordinate of 0″. While the changes produced are not very marked, we notice that the maximum of 1912 is somewhat reduced, that that of 1864 is increased, and that of 1850 diminished, although not destroyed. The important feature, however, of this operation so far, is that we have reduced the average deviation of the whole from ±0″.54 to ±0″.47. That is to say we have improved the orbit. Even including the early discarded observations, the average deviation is only ±0″.48. While this improvement does not at first seem very important, yet if we consider that the accidental errors of an unperturbed orbit would amount to over ±0″.25, the improvement, such as it is, it appears is worth while. In our discussion of the "Orbit of Uranus," Popular Astronomy, 1928, **36**, 357, Reprint page 5, we found that for 192° of its orbit as there deduced, where it was unperturbed by unknown planets, the average deviation due to accidental errors was ±0″.34.

What the improvement means may be interpreted as follows: The aphelion of Saturn's orbit lies in longitude 271°.5, or only 18°.5 from the ascending node of the sinusoid. At the nodes the corrections of the proposed orbit are zero, hence only a slight change in the longitude is found to be necessary of Hill's aphelion and perihelion. On the other hand, half way between the nodes the change is marked. This would involve an appreciable change in his adopted eccentricity. At the time of perihelion, according to Hill, the planet should be moving faster than according to my orbit. I think, therefore, that his eccentricity should be somewhat reduced. But the striking feature of the second row of dots that is brought out more clearly than before is that we now have two and a half maxima of equal intensity, well marked, and equally spaced. We find that they can be represented approximately by a sinusoid whose period is 320°, its amplitude 0″.6, and the longitude of its ascending node in 1907.8 at 345°. The eccentricity of Saturn's orbit is only 0.05, and for our present purposes may be neglected.

The question now arises what does this curve mean? The regularity of the sinusoid indicates that the larger deviations shown are not due

to mere accidental errors, but demand an explanation. The period is 26.19 years. We might at first think the curve due to an unknown planet revolving near Saturn, and related to it somewhat as planet *O* is believed to be related to Neptune. Its shape, however, is not that of a curve due to a planetary perturbation, which is practically straight and level for over half a revolution, and sharply pointed near the conjunction of the two planets. Still another, and quite as serious an objection, if not more so, is that in order to produce so large a perturbation of Saturn such a body would have to be massive and very dark, otherwise it could not possibly have escaped detection up to the present time, either visually or photographically. If the perturbation is due to any body at all, it must be to a much smaller one, much nearer to Saturn, in other words to a slow moving satellite. Such a body would be exceedingly interesting from a mathematical standpoint, for not only would its perturbations by the Sun be enormous, but Jupiter would also effect it strongly. Indeed its position would undoubtedly be one of the most troublesome ones in the whole solar system to compute.

It may be remarked here that a perturbation caused by a satellite is a very different thing from a perturbation caused by a neighboring planet, and must be treated in a very different manner. One difference is that the nearer a perturbing planet gets to the one perturbed, the greater will be the displacement produced. In the case of a perturbing satellite the reverse will be the case, for the closer it gets to its primary the less will be its effect. Returning now to Table III, the corrections for the second sinusoid are given in the sixth column, while the last gives the resulting deviations. These are plotted in the lower curve. We notice by the last line of the table that the average deviation of the orbit of Saturn for the past 67 years, as indicated by this lower row of dots, has been reduced from $\pm 0''.54$ to $\pm 0''.27$.

We will now proceed to determine the period and direction of revolution of the hypothetical unknown satellite which we will designate as *U*. In general when a satellite is first discovered, and before its orbit and direction of revolution are known, it makes little difference in its period whether we assume the direction to be direct or retrograde. The former will slightly shorten the period, the latter lengthen it. In the case of this unusual satellite, however, the direction of revolution has a very marked effect, as is readily demonstrated by Figure 2. The period of the sinusoid as we have just shown is 320° or 26.19 years. In the figure let the large circle represent the orbit of Saturn, the planet and its satellite being represented at A, with the latter at eastern elongation. After Saturn has traversed 320° of its orbit to E the satellite will again be at eastern elongation. Half way between these positions at C it will be at the extreme western point of its orbit. So far the orbit of the satellite might be either direct or retrograde, but at B as seen from the Sun it will be in conjunction with Saturn, and it must then be either at d or at r. If the former, its revolution will be direct, and it will have

traversed 170° of its orbit. On the other hand if it is at r, its revolution will be retrograde, and it will have traversed only 10°. The direct revolution corresponds to a period of 13.86 years, the retrograde to a period of 235.7 years. The latter is obviously impossible for a satellite, since Saturn could not hold such a body against the attraction of the Sun. Therefore *U*, if there is such a body, is definitely revolving in a direct orbit, although far more remote from its primary than any other known satellite. Its period expressed in days is 5062, and its mean angular

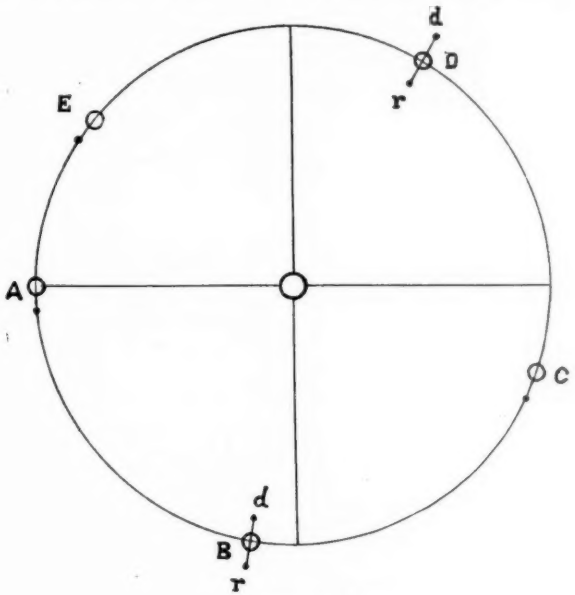


FIGURE 2.
THE ORBIT OF SATURN.

distance at elongation from Saturn as seen from the Sun is 8224″ or 2° 17′ 4″. Its distance expressed linearly is 35,300,000 miles, or 0.380 units, or very nearly the same distance as that of Mercury from the Sun. Its mass is 1/13700 that of Saturn, or 0.303 that of Titan, or 0.56 that of our Moon. It would, therefore, be a very considerable body. The density of Titan is 3.5 times that of water, or about the same as that of our Moon. We shall, therefore, assume this figure for *U*. If its albedo were the same as that of Titan its magnitude would be 0.9 fainter, or 9.2. This as we can readily see is unlikely, or it would have been found before this. It must, therefore, be a comparatively dark body.

Returning now to our second curve, where the sinusoid represents the actual motion of the center of gravity of the planet, the maxima indicate

where Saturn is located farthest ahead in its orbit, *i.e.* to the east, and where the satellite is at extreme western elongation. The nodes indicate where the two bodies are in conjunction. The curve represents a circular orbit, and the line of dots at the descending nodes coincides with it fairly well. At the ascending nodes, on the other hand, it appears that the curve should be pushed back a little. In other words from the descending node to the ascending is in both cases a shorter distance than from the ascending to the descending, in the ratio of about 7 to 9. The satellite, therefore, apparently stays longer on the west side of the planet than it does on the east side. The algebraic sum of the 50 deviations taken from the fifth column of the table during the two complete revolutions of the planet about its center of gravity occurring between the years 1874.0 and 1926.0 is +4″.5. It would, therefore, appear that Hill's zero coördinate is drawn 0″.09 too low. This fact will correct about half of the difference shown above. This difference would indicate a perisaturnium to the east of the planet,—a shorter path and a higher velocity.

With regard to its present position, during my recent visit to the Mount Wilson Observatory, the Director kindly had three photographs of Saturn and its vicinity taken for me on the nights of July 24 and 25, when the heliocentric longitude of the planet was 257°. The coming ascending node in 1933 will be in heliocentric longitude 305°. From this we conclude that on these plates the satellite should be 1°.89 east of Saturn if moving in a circular orbit, and we should expect it to be in nearly the same latitude. Since the orbit must certainly be very eccentric, this distance must be looked on simply as a maximum. The perturbations of Saturn are too small to form even an estimate of the eccentricity of the orbit, but the later observations of the second curve confirm the position of the perisaturnium, and imply that the orbit is eccentric. It is thought, however, that the satellite must have been at least one degree from the planet. This region was accordingly very carefully examined on the two best plates, but the satellite was not found. This was naturally a little disappointing, but it was seen that, as so often happens in such cases, it possibly merely furnished us with a new fact. The plates unfortunately had been somewhat fogged by moonlight, and this fogging rendered a recognition of any star images fainter than magnitude 12 rather uncertain. Titan is an unusually bright body, its albedo being 0.34, or about 5 times that of our Moon. If satellite *U* had been as bright as magnitude 12, or about 0.1 of what I had assumed, I surely would have found it. This would have implied an intrinsic brightness of about that of the lunar maria. I might have found it had it been a little darker. In any case, therefore, if the satellite exists, we have the added fact that it is certainly a very dark body. Dr. Adams kindly agreed last summer to have two or three other negatives of Saturn taken for me with somewhat longer exposures. When these arrive they will be immediately examined, and it is hoped that the satel-

lite will be found upon them.

In closing it may be remarked that whether the satellite is found or not, observations made at Greenwich as well as at Washington indicate that Saturn is now revolving about a point distant 2500 miles from its center of gravity, in a period of 13.86 years, and that during the past 67 years it has apparently made 2.5, but has really already made 5 such revolutions.

PRIVATE OBSERVATORY, MANDEVILLE, JAMAICA, B. W. I., December 15, 1928.

FORTY-FIRST MEETING OF THE AMERICAN ASTRONOMICAL SOCIETY.

The forty-first meeting of the Society was held in affiliation with the American Association for the Advancement of Science in New York City, December 26-29, 1928.

The four sessions for papers were held jointly with Section D in the Physics Building of Columbia University on Thursday, Friday, and Saturday.

President Brown opened the session on Thursday morning and then invited Mr. Schlesinger to take the chair—a good selection for the program, which was made up of papers on parallax and proper motion. These were contributed chiefly by the staffs of the Van Vleck and McCormick Observatories.

In the afternoon the Society had the pleasure of hearing two papers from the Coast and Geodetic Survey, and one by R. H. Curtiss telling of the initiation of regular observing at the Lamont-Hussey Observatory in South Africa. The Lowell Observatory sent a fine set of slides of the planets.

On Friday morning a group of astrophysical papers was given with Professor H. H. Turner, honorary member of the Society, and Mr. Fox, secretary of Section D, presiding. The presidential address of George C. Comstock, entitled "The Atmospheric Refraction," was read on Saturday morning by Mr. Stebbins. Mr. Curtiss was then called to the chair and the remainder of the papers presented.

Thirty-three papers were accepted for the program; twenty-nine were presented; three were read by title; and the fire laws of New York City prevented the exhibition of a Fox Film. The margin between the 270 minutes scheduled for the twenty-nine papers and the 480 minutes actually used for the sessions was not wasted. Professor Turner's contributions to the discussion were especially appreciated. Three lanterns were tried and it is hard to say which was the best one.

At the Friday afternoon joint session of Sections B and D, the Physical, Meteorological, and Astronomical societies, at the American Museum of Natural History, Mr. Nicholson read the address of the

retiring vice-president of Section D, Walter S. Adams, on the possibilities of the proposed 200-inch telescope. Each member probably thought that if this telescope could be devoted entirely to his own particular problem astronomical science would take a step forward. W. J. Humphreys then gave his address on "Samples of Outdoor Physics." He was followed at a "general session" by H. H. Turner, of Oxford, the invited representative of the British Association, who, in "A Scientific Retrospect," carried the audience back to Kepler, Tycho, and Newton. These addresses will be printed in *Science*.

Some of the members are accustomed to the luxury of a rising floor; few had experienced the novelty of going up to the telescope in an elevator until they visited the Observatory on the roof of the Physics Building on Saturday afternoon. Everything looked nice and new and convenient. On Friday the bronze literary lady and the Society were photographed in front of the Columbia University Library.

The Society is especially indebted to Mr. W. J. Eckert and to Mr. Clyde Fisher for the many thoughtful ways in which they effectively worked for the comfort of the members and the success of the meeting.

Some members went to all the receptions and evening lectures, several shows, and the concert of the New York Philharmonic-Symphony concert on Sunday afternoon, ending up with Mr. Shapley's conducted tour through "Galaxies of Galaxies" and return in time to "catch the 10:45 for Yonkers," January 1, 1929.

Since it has become necessary to make certain changes in the Constitution in order to make it consistent with the articles of the recent incorporation, the Council thought it well to use the occasion for a thorough revision of the Constitution. A committee authorized by the Council to consider advisable changes was appointed by the president as follows: F. Schlesinger, F. Slocum, J. Stebbins, chairman. Alliteration of surname and absence of middle name promises unanimity. The committee invites suggestions from other members and promises to give them due consideration. The results of their findings will be submitted to the Society at the next meeting.

The nominating committee, Alice H. Farnsworth, Warren K. Green, chairman, Harlan T. Stetson, after long and presumably careful consideration proposed the following slate:

For Vice-President	R. G. Aitken	1929-1931
Secretary	R. S. Dugan	1929-1930
Treasurer	Benjamin Boss	1929-1930
Councilors	E. S. King	1929-1932
	F. H. Seares	1929-1932

Member of the Division of Physical Sciences, National Research Council:
S. A. Mitchell 1930-1933.

This report was approved by the Council and these nominations will form the official ticket to be submitted to the Society at the annual meeting. The secretary is authorized to invite other nominations,

which, if made by at least ten members and received by the secretary before May 1, will be printed and distributed with the official ballot.

John A. Miller and Heber D. Curtis have been appointed official representatives of the Society at the Fourth Pacific Science Congress, which will be held in Batavia and Bandoeng, Java, May 16 to 25, 1929.

The following persons were elected to membership. The number of members in the Society, with, however, no allowance for unpaid dues, is four hundred eighty-five:

Sten Asklöf, Leander McCormick Observatory, University, Virginia.
Leland S. Barnes, Lehigh University, Bethlehem, Pennsylvania.
Dirk Brouwer, Yale University Observatory, New Haven, Connecticut.
George A. Davis, Jr., 936 Elliott Square, Buffalo, New York.
Guy Emerson, 150 East 73rd Street, New York City.
Vera M. Gushee, Pine Manor School, Wellesley, Massachusetts.
Grace C. Jordan, 345 Central Street, Springfield, Massachusetts.
Charlotte M. Krampe, 1101 15th Street N. W., Washington, D. C.
Paul A. McNally, Georgetown College Observatory, Washington, D. C.
John E. Merrill, 275 Nassau Street, Princeton, New Jersey.
Nicolas Perrakis, Care of Prof. C. Fabry, University of Paris, Paris, France.
Dirk Reuyl, Leander McCormick Observatory, University, Virginia.
L. V. Robinson, Harvard College Observatory, Cambridge, Massachusetts.
Helen F. Story, Wellesley College, Wellesley, Massachusetts.
Fred L. Whipple, 1298 E. 4th Street, Long Beach, California.

The attendance broke the record previously held by the thirtieth meeting at Mt. Wilson by a considerable margin. The following members were present:

Sebastian Albrecht
Leah B. Allen
Adelaide Ames
L. B. Andrews
L. S. Barnes
Ida Barney
S. G. Barton
Harriet W. Bigelow
William Bowie
Dirk Brouwer
E. W. Brown
Leon Campbell
Annie J. Cannon
C. A. Chant
W. A. Cogshall
C. H. Currier
R. H. Curtiss
G. K. Daghlian
A. E. Douglass
R. S. Dugan
J. C. Duncan
W. J. Eckert
W. S. Eichelberger
Alice H. Farnsworth
E. A. Fath
J. W. Fecker
G. C. Fisher
Philip Fox
Caroline E. Furness
Carolyn Gesler
C. H. Gingrich
W. K. Green
Vera M. Gushee
Mrs. H. T. Hall
J. C. Hammond
Margaret Harwood
William Henry
W. J. Humphreys
A. G. Ingalls
Harold Jacoby
Grace C. Jordan
M. F. Jordan
D. K. Kazarinoff
M. S. Kovalenko
W. D. Lambert
Mrs. C. L. Lewis
Morris Liferock
F. B. Littell
Hazel M. Losh
C. A. R. Lundin
P. A. McNally
D. B. McLaughlin
E. S. Manson, Jr.
R. W. Marriott
Antonia C. Maury
A. D. Maxwell
C. E. K. Mees
J. E. Merrill
J. A. Miller
S. A. Mitchell
Charlotte E. Moore
D. W. Morehouse
F. R. Moulton
J. J. Nassau
S. B. Nicholson
Jesse Pawling
D. B. Pickering
J. H. Pitman
J. M. Poor
I. G. Priest
Harry Raymond
Dirk Reuyl
E. D. Roe, Jr.
Alice Rogers
C. E. Rogers
J. T. Rorer
Jan Schilt
Frank Schlesinger
Harlow Shapley
B. W. Sitterly
Frederick Slocum

C. L. Stearns	A. B. Turner	R. L. Waterfield
Joel Stebbins	H. H. Turner	C. T. Whitehorn
H. T. Stetson	Mrs. P. S. Underwood	E. L. Williams
J. Q. Stewart	R. N. Van Arnam	Emma T. R. Williams
R. M. Stewart	George Van Biesbroeck	Marjorie Williams
James Stokley	Piet van de Kamp	R. E. Wilson
N. W. Storer	W. J. Vinton	J. E. G. Yalden
Henrietta H. Swope	Alexander Vyssotsky	Jessica M. Young

The list may not be entirely complete but is nearly so. The following attendance of visitors was recorded: Edward Arnott, A. D. Carpenter, E. H. Clarke, W. M. Cody, Mrs. Dugan, Mrs. Duncan, Miss Isabel Harris, Y. Hagihara, Mrs. Hammond, Miss Rebecca Hubbell, L. Hufnagel, Miss Selma Kenarney, Miss Eleanor Knight, S. A. Korff, Mrs. Kovalenko, Raymond Lewis, Mrs. Littell, Mrs. Mary F. Losh, Mrs. Lundin, Miss Lundin, Miss Georgette Maulbetsch, Mrs. Mitchell, C. M. Olmsted, Harry W. Reddick, James Robertson, J. Rosenman, Mrs. Slocum, W. M. Smith, Arthur Snow, C. L. Snow, G. W. Walker, Miss Henrietta Young.

It was announced that the next meeting would be held at the Dominion Observatory, Ottawa.

THE ATMOSPHERIC REFRACTION.

By George C. Comstock.

(Presidential Address delivered before the Society in New York City, December 29, 1928.)

"There is perhaps no branch of astronomy on which so much has been written as this (refraction) and which is still in so unsatisfactory a state." The words here quoted are those of Newcomb published a quarter century ago as a scholium to his own presentation of refraction theory. In the present paper it is purposed to inquire to what extent the progress of science in the past two decades has ameliorated the condition thus deplored and what further progress in this field stands in immediate demand and prospect.

As Newcomb saw the situation its theoretical difficulties "arise from the uncertainty and variability of the law of diminution of the density of the atmosphere with height and also from the mathematical difficulty of integrating the equations of the refraction for altitudes near the horizon, after the best law of diminution has been adopted." The problem presented to the astronomer is, in fact, to trace backward along its path a ray of light which has reached the surface of the earth at an observed angle with the plane of the horizon; to determine at every point of that path the deflecting effect of the atmosphere and by summing all these partial influences to determine the direction of the ray before it came under the earth's disturbing influence. The technical importance of the problem calls for no words of emphasis before a gathering of astronomers.

The primary difficulty lies in the unknown constitution of the

atmosphere everywhere save within a shallow stratum at the bottom. Historically the path of progress in our problem has been through successive assumptions regarding this constitution, guesses, which more or less have justified themselves by furnishing *seriatim* numerical values of the refraction that are increasingly free from the reproach of being demonstrably wrong. Bradley, Laplace, Bessel, Ivory are some of the names associated with the earlier cultivation of this field and through them and others there was long ago developed for moderate zenith distances, a fairly approximate knowledge of the amount of refraction to be expected under varying meteorological conditions. In Newcomb's time the high water mark of progress was represented by the Pulkowa Refraction Tables, based upon a theory due to Gyldèn. In this refraction theory, and in those of his predecessors, the atmosphere is conceived as a gaseous envelope of the earth of unvarying composition, whose density, from bottom to top might be represented by a continuous mathematical function. The independent variable in this function is height above the earth's surface and into it there enter certain parameters whose values admit of experimental determination, usually in more than one way; *e.g.* the air's coefficient of thermal expansion and the so-called constant of refraction, which is intimately related to the refractive index of air. The somewhat divergent values of these parameters obtained through different methods of determination have long been recognized as furnishing a useful control upon these methods and upon the theories into which they enter; of which more anon.

The Pulkowa Refraction Tables have rendered and still render excellent service in astronomical practice, although for objects seen near the horizon their reliability rests under grave suspicion. Their theoretical basis is even more strongly impugned. The earth's atmosphere is not a homogeneous gas, but rather a mixture of several gases in which the thoroughness of the mixing varies greatly from place to place, and is believed to be wholly absent from the upper strata. The parameters above considered must be assigned different values for the mixture and for its several component gases where these are segregated. In general, the atmospheric density may be considered an analytical function of height above the soil or sea only in the sense that the surface of the sea may be represented by such a function. In each case the general form and condition may be so described by one or more suitable equations, but for sea and air alike the attempt to include under mathematical symbols each billow and ripple leads to hopeless complexity. But it is these billows and ripples in the atmosphere, especially near the horizon, that clog the mathematical machinery and lead to its ultimate futility. Their recognition as an essential feature of the refraction problem constitutes in itself an important advance.

Nevertheless, following in substance the old methods, a considerable improvement upon the Gyldèn refraction theory has been made by Radau, who, avoiding certain errors of his predecessors, and introduc-

ing into theory an essentially new parameter to represent the aqueous vapor content of the atmosphere, has measurably improved theory and, in minor degree, has served the needs of the observer through new tables of the refraction. Radau's tables as published in the *Paris Mémoires* have been transformed by deBall into the conventional form introduced by Bessel. A notable feature of these tables is that, for the first time, there are furnished numerical values of the refraction for stars observed below the true horizon, *i.e.* for zenith distances extending to 91°. The accuracy and reliability of these refractions at negative altitudes still awaits adequate test. The only data pertinent to this end that are known to the author are contained in his own discussion of sunset observations at the sea horizon. These show traces of systematic error of a seasonal character but are fairly consistent among themselves, the probable error of a single such observation being about a minute of arc. A large part of this error must be attributed to sources other than refraction. Pending a more adequate test of these refractions for negative altitudes it must be regarded as of considerable theoretical interest that the series employed for their computation are shown to be convergent for zenith distances considerably exceeding ninety degrees. The refractions themselves should find increasing application in aerial navigation.

The refractive index of air and the coefficient of its thermal expansion, which appear as parameters in the refraction theory, enter into refraction tables as constants so determined from astronomical observations as best to satisfy the observations themselves, *i.e.* the refraction tables in current use are substantially equivalent to interpolating curves which present in convenient form a compendium of the refractions hitherto observed under a wide range of meteorological conditions but without much discrimination as to when and where made. The author has shown, elsewhere, that for most purposes these elaborate tables may be replaced by a simple formula, in which the parameters above considered appear undisguised. Let us turn now to a comparison of their astronomical values with laboratory determinations of the physical constants to which they are related.

In the case of the refractive index of air, represented by the refraction constant of the astronomer, there is a gratifying agreement of results. From a discussion of ten extensive series of meridian altitudes, made at five European observatories and extending over several decades of time, deBall finds for an assumed standard condition of the atmosphere, a consistent set of values for this constant that cluster closely about 60″.15 as an adopted mean result. Laboratory determinations of the refractive index of air give for like conditions 60″.19 as the value of this constant. Any attempt to assign probable errors to these results would be useless but their divergence of less than one part in a thousand, if not to be viewed as a lucky accident, furnishes some index to the measure of uncertainty inhering in the results. Some further in-

sight into the matter may be obtained through comparison of the values given above with Comstock's result of thirty years ago, obtained by measuring long arcs in the sky (120°) by means of the Loewy prism apparatus. These results, when reduced to the standard atmospheric conditions of deBall give 60".17 as the value of the refraction constant The three values thus obtained through entirely different methods, each quite independent of the others, show a substantial agreement that not only inspires some confidence in the numerical accuracy attained but also tends to discredit a practice formerly current among astronomers, of establishing harmony between discordant series of declination observations by altering the refraction to fit the case. Doubtless the refraction is systematically different at different observatories, possibly different for different instruments at the same observatory, but for the most part such differences arise from well-known physical sources and should be taken into account by due reference to them. The scope for further residual effects from unknown sources appears to be much less than has hitherto been assumed.

The physical and the astronomical determinations of the thermal coefficient of expansion of air, an important parameter in the refraction theory, present unwelcome diversities of value, the astronomical result being considerably larger than that found in the laboratory. In view of the manner in which this constant is determined, astronomically, comparison between high and low temperature observations, it seems probable that the summer and winter refractions differ systematically *inter se,* from influences not sufficiently taken into account by theory. The Pulkowa Refraction Tables present a rather futile recognition of an annual term in the refraction but its effect upon astronomical practice has, until very recently, been inappreciable. The same may be said of other alleged diurnal and cosmic terms.

The results above considered have been reached through an ever increasing complexity of refraction theory and one therefore notes with pleasure Emden's attempt to simplify that theory without undue loss of numerical accuracy in its application. At present, data for a definitive judgment of the success attained seem to be lacking.

During the past decade a much more radical step has been taken by Harzer, in substituting for mathematical fictions concerning the composition of the atmosphere, the concrete results of modern meteorological investigation of its lower strata. The deviations suffered by a ray of light in passing through an atmosphere thus empirically defined he obtains through laborious mechanical quadratures instead of by the customary integrations. Hypotheses regarding the upper atmosphere are not entirely avoided, *e.g.* that its refractive effect becomes negligible at and above a height of 85 kilometers; that below this level a sharp distinction is to be drawn between the effects of troposphere and stratosphere, regions of the atmosphere whose relation to the refraction is widely different, etc. The exact nature and validity of these and other

assumptions regarding the upper atmosphere appear to be of minor consequence since even considerable errors affecting them would produce little change in the resulting refractions. This, refraction, is almost wholly due to the lower atmospheric strata whose average composition and character are directly given by physical observation.

The refractive index of air and the other parameters upon which Harzer's numerical results depend are, for the most part, laboratory constants and in no case depend upon observed values of the refraction. With reference to them, therefore, Harzer's refractions may be described as theoretical results whose relation to practical astronomy remains to be determined. A provisional comparison between them and the tables of Gyldèn and Radau shows a very satisfactory agreement for normal circumstances and moderate zenith distances. It should not escape notice that Harzer's appeal to physics and meteorology, as constituting in themselves and without reference to astronomical observation an adequate basis for refraction tables, has in some respects greatly complicated the problem in hand. In lieu of the two, three, or four parameters used by his predecessors, Harzer finds need for twice as many. For the computation of his numerical refraction in a given case there is required a process much longer and more burdensome than that hitherto employed, *e.g.* these new refractions commonly involve and depend upon not only the current temperature and barometric pressure at the time and place of observation but require also such further elements as the time of day at which the observation was made (diurnal variation), the time of year (annual variation), color of the star (dispersion effect), wind velocity (effect of, upon barometric pressure), and discrimination may be required between observations made upon opposite sides of the zenith. The astronomer with long routine experience with meridian observations may be unpleasantly impressed by such an array of new factors to be considered, even though their numerical effect upon the computed refraction is not very great. Their introduction into refraction ought to produce a welcome improvement in the results of observation but the willingness of the practical astronomer to incur their burden will be in some measure damped by the assurance that these refractions are prepared for use at only a single observatory (Kiel) and that their use elsewhere has as little, or as much, justification as the similar use of any other tables. The normal atmospheric regimen varies from place to place and purely local conditions of topography, architecture, or even the optical glass employed may require appreciable modification of the refractions furnished by any table, *i.e.* the refraction must be custom made.

Summarizing the results above set forth, we may surmise that for moderate zenith distances (75°) and for average conditions such as are represented in the mean of a considerable number of observations of a given set of stars, the errors of the best existing refraction tables are probably of the order of a tenth of a second of arc. But this degree of

precision is far from being realized for an isolated observation. It has been abundantly shown, by Schlesinger and others, that very often, the actual refraction fluctuates through a range of values covering a large fraction of a second. The current explanation of this flickering, or unsteadiness of the star image, assumes the presence of bodies of air of varying density that are borne by the wind between telescope and star. A well known principle (Oriani-Laplace) suggests that such fluctuations may be taken into account by computing the refraction with the instantaneous value of the temperature and pressure at the telescope objective, but for the present this suggestion seems of little value and the burden of dealing with rapid changes in the refraction, from momentary flickering to pulsations of longer period, continues to rest with the observer rather than with the computer.

A more serious question of atmospheric change arises in connection with possible variations of longer period affecting the refraction, *e.g.* such as might be caused by a periodical tilting of the strata of homogeneous air out of their normal position or by the substitution of a wedge of air of abnormal density in place of the normal stratum of homogeneous air bounded by parallel faces. Barometric "highs" and "lows" may conceivably produce local disturbances hard to evaluate or describe but sufficient in amount to exert an appreciable influence upon the refraction. The well-known phenomenon called inversion of the temperature gradient, *i.e.* an increase instead of decrease of temperature with increasing height, appears at first sight to be a promising source of abnormal refractions but, save very near to the horizon, its effects seem to be unimportant. The sun's effect upon atmospheric equilibrium presumably varies from morn to midnight and this influence may possibly cause systematic deformation of the atmosphere, the barometric tide, with resulting perturbation of the refraction, (Harzer's diurnal term). But for the present these and other possibilities are unverified hypotheses, question marks, calling for further research.

Appeal has been made, by Varnum, to some such atmospheric deformations to account for and coördinate certain puzzling anomalies found in the determination of time and declination, and if it were permissible to assume their presence in adequate amount much that is now obscure might find plausible explanation. Unfortunately, meteorological observation seems to give little support to the assumed existence of atmospheric abnormalities of the required order of magnitude and persistence.

Thus far we have considered the refraction solely from the astronomer's point of view, but its character and amount are of equal consequence to the navigator, at sea or in the air. In this connection it is noteworthy that, at present, astronomer and navigator largely ignore each other's relation to the refraction problem. In the course of a recent long sea voyage, on American ships, I have been told by an intelligent navigating officer that to fix his ship's position he prefers to observe

stars at an altitude not greater than twenty or twenty-five degrees "because higher up in the sky the refraction becomes too uncertain." Astronomically nothing could be more heterodox than diminishing precision with increasing altitude. The captain of an ocean liner pointed out to me in the Red Sea the official legend on his chart warning against unknown currents there supposed to be a menace to navigation. *Prima facie* their existence was confirmed by the circumstances of the moment, when an excellent noon sight placed the ship seven miles off her dead reckoning position. The captain shrewdly remarked that to produce this effect the alleged current must have been running directly into the teeth of half a gale then blowing, and he offered as a more plausible explanation of the circumstances that the noon sight, result of concurring observations by three officers, had been vitiated by an error of seven minutes of arc in the refraction employed for their reduction. A refraction error of seven minutes at an altitude of some sixty degrees presents to the astronomer an incredible paradox, even though the refraction tables employed were astronomically obsolete and long since discarded. Bessel's refractions are still retained in the *American Practical Navigator* (Bowditch).

Nevertheless, the opinion of the navigator is not to be summarily rejected because inconsistent with astronomical experience. The astronomer measures the angular distance of a star from a zenith mechanically determined, and the refraction errors with which he is confronted arise from abnormalities in the atmospheric strata overhead. The navigator measures his altitudes from the sea horizon and into the refraction as understood by him, there enter all the sources of error that vex the astronomer and in addition thereto all those that affect the light rays coming from the visible boundary between sea and sky. The latter may be much greater in amount than the former and from the standpoint of theory and practice alike it seems a matter of some importance to increase present knowledge concerning their character and amount. In practice the effect of such errors comes through what the navigator calls Dip of the Horizon, and it may be remarked that within recent years the increasing size of ships has considerably increased the amount and importance of this term. That it is affected by considerable irregularities due to refraction is generally believed, but concerning the amount of these irregularities and the conditions that produce them available information seems inconclusive. Even the amount of refraction affecting the sea horizon under normal conditions seems to be a matter of some doubt.

To illustrate the existing status we may assume that the path of an approximately horizontal ray of light coming from horizon to ship and curved *en route* by refraction, may be represented by an arc of a circle. The radius of this circle being inversely proportional to the curvature will serve as a measure of that curvature and of the refraction that produces it. Geodetic practice assigns to this radius, under normal

conditions on shore, a value some six or seven times the radius of the earth, 25,000 miles, and this value is adopted for marine use by such esteemed authorities as Bowditch and Newcomb. But the long series of observations conducted at sea, under Carnegie auspices, lead to an average value of this radius some three or four times that of the earth, *e.g.* 14,000 miles. Corresponding to this value the normal dip of the horizon is nearly ten per cent less than that given in the official American manual of navigation.

Under abnormal conditions the radius of curvature for the light ray and the resulting dip of the horizon may vary widely from both of the standard values above considered. Thus, the Carnegie observations are summarized in a statement which I quote, as follows: "The observed values of refraction have not raised the horizon more than 2'.4 nor depressed it more than 2'.0 below the position it would be seen if no refraction existed." The radii of curvature corresponding to these two values are approximately —1.5 and +0.8 times the terrestrial radius, and the transition from one value to the other is made through infinity, not through zero. The observed negative radius is obviously a case of "looming," the marine equivalent of mirage. The very small positive value of the radius may be compared with a phenomenon familiar in western America, the apparent nearness of objects really much more distant than they seem.

In marked contrast with the foregoing small range of abnormality in the position of the horizon, the U. S. Navy Department, apparently adopting the results of certain terrestrial observations made about the shores of the Adriatic Sea, opines that abnormalities in the position of the horizon may amount to as much as half a degree. The divergence of this estimate from the values found at sea, *supra,* need not be taken too seriously since in explanation recourse may be had to difference of height above sea at which the respective observations were made and to possible differences of atmospheric conditions along shore and in the open sea. It should also be noted that the Carnegie observations do not give directly the elevation of a determinate point of the horizon, but only the algebraic sum of the elevations of two such points diametrically opposite each other. The effect of inclined atmospheric strata and other like disturbing causes may be to a large extent masked in this sum. Nevertheless, after all such allowances are duly made there remain substantial discrepancies among the authorities. The sum of the available evidence seems to justify the common belief in the existence of considerable abnormalities in the dip of the horizon, possibly amounting to as much as the seven minutes above considered in the Red Sea case. Of the time and place of such abnormalities and of the indices by which their presence may be recognized, information seems to be almost wholly lacking. The cause most frequently assigned them is a difference of temperature between earth and air, or sea and air, but concerning this influence the evidence is conflicting. It is quite possi-

ble that such temperature differences do play a rôle in the drama, perchance as index if not as cause. As to the quantitative significance of this index nothing seems to be known.

The whole case regarding the presumed instability of the sea horizon is one in which an addition to existing knowledge seems an urgent need. Mariner and astronomer alike have an interest in the problem and each should contribute to its solution. The astronomer's part in the research might well be made through installation at sundry places commanding a distant horizon, of one or more photographic telescopes, of very modest size, but so arranged as to furnish, as continuously as possible, an automatic record of the elevation of the horizon, or of a distant terrestrial point. This should be accompanied by a study of local conditions attending disturbance of that altitude. The mariner's contribution in the matter presents greater difficulties, arising in part from inadequacy of instrumental equipment and in part from the circumstance that in general his observations must be made from a moving platform whose position is to be independently determined for each observation of the horizon. It is obvious that some of these difficulties may be overcome through observations made near shore or made at suitably chosen marine stations, such as the Florida Keys or the smaller islands of the Red Sea. An extended series of observations of the time of sunrise or sunset at the sea horizon could be made to furnish much pertinent information, and other suggestions are not far to seek. With such considerations in mind there is greatly to be deplored the withdrawal from this field announced a decade ago by the Carnegie Department of Terrestrial Magnetism.

In the foregoing lines scant reference is made, or none at all, to many refraction problems of current interest and importance from the standpoint of both theory and practice. The effect of atmospheric dispersion of light has been much discussed by astronomers. The widespread use of photography as an aid to astronomical research has brought new problems requiring some change in the treatment of refraction. The proposed cosmic refraction, *e.g.* an effect of the sun's atmosphere, is of great theoretical interest, etc. All such matters lie beyond the present purpose and must here be passed by. But a passing word may well be given to the present outlook for improvement in current astronomical practice where there is involved a demand for high precision in the refractions employed. It seems probable that the next forward step in this field is to be taken through increased knowledge of the atmospheric conditions immediately surrounding the place of observation. The refractions now currently employed relate to an average condition of the atmosphere in some undefined part of the earth. This status, suitably modified for local temperature and pressure, is assumed to represent the conditions under which a given observation is made. This was tolerable a generation ago, but recent advances in applied science make such procedure seem at least obsolescent if not

actually reprehensible.

The lower strata of the atmosphere have become a highway of commerce and there is available concerning their day-to-day condition a body of information undreamed of in Newcomb's time. By promise if not by present performance, the radio contains a store of information concerning the upper atmosphere that may well find application to refraction theory.

Is it too visionary to hope that in the near future the meridian astronomer may have placed at his service some equivalent of the present weather map that will currently indicate for the region within 100 kilometers of his observatory the actual distribution of density in the atmosphere immediately surrounding him and extending upwards even to the limits of the troposphere? Is it too much to hope that he will learn how to use these new data to the great improvement of his computed refractions, turning them from mean into osculating elements, if one may borrow a phrase from celestial mechanics? These are questions for the future but surely it is a mark of progress already achieved that they may now be put with some chance of respectful consideration.

The commonplace remark that progress makes more questions than it solves is almost perforce suggested here. Some old difficulties have been surmounted and the field of research has been greatly widened but its problems still offer to a coming generation, in increasing measure, the promise of an abundant harvest to be reaped.

(To be continued.)

PLANET NOTES FOR MAY

By CLIFFORD E. SMITH.

The *Sun* during May will be moving northeast from the central part of Aries to the central part of Taurus. On May 9 there will be a total eclipse of the sun which will be invisible in North America. For details see POPULAR ASTRONOMY for January, 1929, page 32, or the *American Ephemeris* for 1929. The positions of the sun on May 1 and May 31 will be, respectively: R.A. $2^h\,31^m$, Decl. $+14°\,52'$; and R.A. $4^h\,29^m$, Decl. $+21°\,49'$.

The phases of the *Moon* will occur as follows:

Last Quarter	May	1 at	7 P. M.	C.S.T.
New Moon		8 "	12 P. M.	"
First Quarter		15 "	3 P. M.	"
Full Moon		23 "	7 A. M.	"

The moon will be at perigee on May 10, and at apogee May 26.

Mercury will be moving from the western to the eastern part of Taurus. On May 10 it will be in conjunction with the moon, and on May 15, at greatest elongation east. During the middle of the month it will set about an hour and a half after the sun.

Venus will appear practically stationary in the southern part of Pisces. On May 7 it will be in conjunction with the moon, and on May 26 it will reach its greatest brilliancy for this elongation. During the middle of the month it will rise about two hours before the sun, and thus will be a morning star.

Mars will move from the eastern part of Gemini to the central part of Cancer. On May 14 it will be in conjunction with the moon. It will also be at aphelion on the same date. During the middle of the month it will be on the meridian about $4^h\ 30^m$ P.M. Standard Time.

Jupiter will be in conjunction with the sun on May 14, and thus will be too near the sun to be observed.

Saturn will be in western Sagittarius, and its apparent motion will be retrograde. On May 25 it will be in conjunction with the moon. During the middle of the month it will be on the meridian about $2^h\ 30^m$ A.M. Standard Time.

Uranus will be in the southern part of Pisces. On May 6 it will be in conjunction with the moon. During the middle of the month it will rise about three hours before the sun.

Neptune will be in Leo near Regulus. Its apparent motion will be retrograde until May 10. On May 16 it will be in conjunction with the moon. On May 20 it will be at quadrature east of the sun, and thus will be on the meridian about 6:00 P.M. Standard Time.

Occultations Visible at Washington.

[From the *American Ephemeris.*]

Date 1929	Star's Name	Magnitude	IMMERSION Washington C.T. h m	IMMERSION Angle from N °	EMERSION Washington C.T. h m	EMERSION Angle from N °	Duration h m
May 1	40 B. Capric.	6.2	4 7	93	5 35	235	1 28
13	λ Cancri	5.9	23 58	52	0 26	340	0 28
15	η Leonis	3.6	19 42	106	20 54	320	1 12
19	γ Virginis	2.9	1 8	100	2 8	319	1 0
21	8 Librae	5.4	18 6	111	19 11	313	1 5
21	α Librae	2.7	18 13	114	19 20	310	1 6

VARIABLE STARS.

Monthly Report of the American Association of Variable Star Observers, for the Month ending February 28, 1929.

Observations for the month just ended prove almost as numerous as for the previous month. There is a thirty per cent increase over the corresponding month of February, 1928. This speaks well for the zeal of our members, and the records show some interesting features for many of the variables.

The outstanding feature of the month is the second drop to minimum of the variable SU Tauri. At the time of this writing (March 10) the variable registers magnitude 12.7. The recent caprices of this star may be likened to those of SS Aurigae during the month of January last, but in the reverse order. Where SS Aurigae presented a sort of double maximum at that time, SU Tauri has given us a double minimum. These variables demand our constant attention, if we are to solve the enigma which they present.

VARIABLE STAR OBSERVATIONS RECEIVED DURING FEBRUARY, 1929.

Dec. 0 = J.D. 2425581; Jan. 0 = J.D. 2425612; Feb. 0 = J.D. 2425643.

J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.
V Scl	R And	T Phe	— Cas	S Psc	X Cas
000339	001838	*002546*	004756b	011208	014958
585 10.8 Bl	619 9.2 Ch	582 9.4 En	641 11.0 L	617[14.0 L	624 11.8 B
592 11.1 Bl	621 9.6 Ah	582 8.8 Bl	653 10.8 Sf	630[13.2 L	640 12.9 Pt
603 12.1 Bl	622 9.7 Ah	586 9.5 Sm	W Cas	641 14.2 L	U Per
S Scl	624 9.6 Ah	592 9.7 Bl	004958	S Cas	015254
001032	625 9.6 Lg	592 9.8 En	624 8.8 B	011272	625 8.4 Wy
582 7.6 En	631 9.9 Wd	593 9.8 Ht	625 9.6 Wy	622 12.0 Wy	630 8.0 Wy
582 7.2 Bl	632 9.6 Al	594 10.5 Sm	631 9.3 Bw	633 12.0 Sb	631 8.4 Bw
582 7.6 Ht	632 9.9 Sb	603 9.9 Bl	638 9.7 Wy	638 12.0 Wy	632 8.2 Al
586 7.8 Ht	637 9.9 Lg	609 10.6 Dr	638 9.0 Pt	640 11.9 Pt	633 8.3 Sb
586 7.4 Sm	638 9.6 Pt	612 10.5 Bl	639 8.7 Jo	650 11.7 B	640 8.1 Pt
592 7.7 Bl	641 9.8 B	612 10.6 Ht	646 8.8 Jo	651 12.2 Sb	641 8.4 B
592 7.7 En	641 10.0 Ah	615 10.8 Dr	647 9.8 Bw	U Psc	642 8.0 Ah
593 7.9 Ht	642 9.8 Al	623 11.2 Dr	654 9.9 Jo	011712	643 8.1 Ah
594 7.9 Sm	643 10.3 Ah	641 12.1 Dw	659 10.4 Bw	617[14.1 L	651 8.1 Sb
603 8.6 Bl	646 10.0 Sb	W Scl	U Tuc	622[14.1 Lg	653 8.4 Bw
605 8.8 Ht	650 10.1 Sb	*002833*	*005475*	630[12.8 L	655 8.0 Sb
609 8.2 Dr	S Tuc	615 13.4 Dr	582 11.8 En	RZ Per	658 8.9 Al
612 9.2 Bl	*001862*	623 13.4 Dr	582 11.6 Sm	012350	S Ari
612 9.0 Ht	582 10.0 En	Y Cep	585 11.2 Bl	632 8.4 Al	015912
615 8.9 Dw	582 10.0 Sm	003179	589 11.2 Sm	641 9.2 B	626 12.8 B
615 8.8 Dr	582 10.2 Bl	625[13.6 L	593 11.2 En	642 8.7 Al	640 13.8 Pt
619 8.9 Dr	589 10.8 Sm	640[14.4 L	593 11.2 Ht	R Psc	641 13.8 B
623 9.0 Dr	592 10.8 Bl	653[13.6 Bw	596 11.0 Bl	012502	R Ari
640 10.2 Dw	593 10.7 En	U Cas	603 10.9 Bl	619 9.9 Ah	021024
X And	593 10.7 Ht	004047	612 10.5 Bl	621 9.6 Ah	613 8.4 Ah
001046	603 11.5 Bl	615 13.2 L	612 10.3 Ht	622 9.6 Ch	619 8.4 Ah
619[13.0 Ch	612 12.3 Bl	622 13.5 B	Z Cet	622 9.8 Ah	621 8.7 Ah
623[14.1 Lg	S Cet	625 13.5 L	*010102*	624 9.9 Ah	622 8.7 Ah
643[12.8 Lj	*001009*	628[13.3 Ch	617 10.6 L	631 9.8 Eb	624 8.7 Ah
646[13.8 Bw	609 10.1 Ch	633[13.3 L	627 11.3 L	631 9.6 Kz	624 9.2 Wy
T Cet	617 9.5 L	646[13.3 Bw	640 12.6 Pt	632 9.8 Al	625 8.8 Ch
001620	619 9.4 Ch	651[13.2 Sb	641 11.8 L	633 9.8 Ah	626 8.6 B
617 6.5 L	621 9.2 Lg	RW And	U Scl	640 10.1 Pt	628 8.7 Ah
627 6.5 L	623 9.4 An	004132	*010630*	641 10.3 Ah	630 8.8 Ah
641 6.4 L	626 9.2 Ch	624[13.7 B	586[13.2 Bl	643 10.6 Ah	633 8.7 Ah
T And	627 9.5 L	V And	619[13.5 Dr	RU And	638 9.5 Wy
001726	631 9.8 Sf	004435	627[13.2 Dr	013238	639 8.9 Jo
619 11.8 Ch	534 8.9 Lg	624[13.7 B	641 13.5 Dw	622 11.4 Lg	640 9.1 Pt
624 12.5 B	638 8.2 Sf	X Scl	U And	626 11.5 Ch	641 9.6 Ah
638 12.8 Pt	638 8.7 Pt	*004435*	010940	632 11.2 Al	642 9.5 Ah
T Cas	641 8.7 L	586[13.6 Bl	615 12.1 L	634 11.0 Lg	642 9.1 Fd
001755	642 8.6 An	RR And	622 11.9 Lg	640 11.2 Pt	643 9.7 Ah
615 11.9 L	653 8.3 Sf	004533	622 11.2 B	660 10.7 Wn	646 9.5 Jo
619 11.7 Ch	T Scl	623[14.1 Lg	627 11.5 L	Y And	W And
625 12.0 Wy	*002438a*	624 13.2 B	628 10.7 Ch	013338	021143a
625 12.2 L	609 9.2 Dr	642[12.6 Al	632 10.2 Al	613 9.6 Ch	612 12.8 Ch
626 11.9 B	615 9.4 Dr	RV Cas	634 10.4 Lg	622 8.9 B	624 12.2 B
632 11.9 Al	619 9.5 Dr	004746a	641 11.2 L	629 9.0 Ch	631 12.3 Bw
633 12.1 L	623 9.6 Dr	615[14.7 L	642 10.5 Al	632 8.3 Al	640 12.3 Pt
638 12.2 Pt	641 10.5 Dw	625[14.7 L	UZ And	640 8.7 Pt	646 12.3 Bw
638 12.2 Wy	RR Scl	641[14.4 L	011041	642 8.8 Sf	T Per
642 12.1 Al	*002438b*	— Cas	615 14.1 L	658 8.9 Al	021258
R And	615 12.9 Dr	004746b	627 14.2 L	660 9.4 Wn	611 9.0 Ch
001838	623 13.0 Dr	615 10.7 L	628[12.4 Ch	X Cas	625 9.1 Ch
610 9.1 Ch	641 13.0 Dw	625 10.7 L	641 14.1 L	014958	625 9.0 Wy
613 9.4 Ah		638 10.6 Pt	644 13.1 B	610 12.6 Bn	627 8.6 Pt
619 9.6 Ah		640 10.8 Sf	646 13.9 Bw	624 12.6 Bn	638 9.0 Wy

VARIABLE STAR OBSERVATIONS RECEIVED DURING FEBRUARY, 1929.

J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.
T PER	S PER	R TRI	X CET	R TAU	X CAM
021258	021558	023133	*031401*	042209	043274
640 8.8 Ah	623 9.3 Ch	650 9.6 Wn	627 9.4 L	626 12.0 B	617 13.1 By
641 8.8 Ah	625 9.2 Wy	653 9.3 Sf	638 10.3 Wy	627 11.6 Pt	620 13.3 By
642 8.8 Ah	627 8.6 Pt	660 8.9 Wn	640 10.2 L	W TAU	624 13.9 Wy
Z CEP	638 9.4 Wy	W PER	642 10.5 An	042215	625 13.6 By
021281	639 9.1 Al	024356	644 10.7 B	625 9.5 Lg	626 13.7 By
615[13.8 L	640 9.2 Ah	625 10.5 Wy	645 10.4 Cl	625 10.2 Wy	627 12.6 Pt
627[13.8 L	641 9.3 Ah	626 10.1 B	647 10.6 Bw	627 9.3 Pt	628 13.5 By
640[13.8 Sf	642 9.2 Ah	627 10.5 Pt	Y PER	631 9.9 Kz	641 11.8 By
641 13.8 L	650 9.2 B	633 10.4 Gi	032043	631 9.5 Eb	642 11.4 Wy
o CET	658 9.2 Al	633 9.6 Sb	625 10.6 Wy	633 9.8 Gi	643 11.6 By
021403	R CET	638 10.3 Wy	627 10.0 Pt	637 8.9 Lg	R DOR
582 6.4 En	*022000*	639 9.7 Jo	638 10.7 Wy	638 10.0 Wy	*043562*
583 6.6 En	617 13.5 L	646 9.6 Jo	646 9.7 Jo	639 9.5 Jo	582 5.6 En
586 5.9 Sm	619[12.0 Ch	646 9.9 Cl	650 10.4 B	648 9.4 Gi	582 5.2 Ht
593 7.2 En	627[12.9 L	648 10.2 Gi	654 10.0 Jo	649 9.2 Jo	582 5.3 Bl
597 7.5 En	641 12.3 L	651 10.1 Sb	R PER	654 9.2 Jo	583 5.4 Sm
601 7.2 Ch	RR PER	654 9.4 Jo	032335	S TAU	586 5.1 Ht
611 7.8 Ch	022150	R HOR	621 8.4 Lg	042309	590 5.2 Sm
613 7.7 Ah	615 13.5 L	*025050*	624 9.0 Wy	641[13.4 B	592 5.4 En
613 7.7 Wf	627 13.9 L	582 12.1 Ht	627 8.7 Pt	T CAM	593 5.2 Ht
615 7.9 Ch	646[13.7 Bw	582 12.2 Bl	631 9.4 Kz	043065	596 5.2 Bl
616 7.3 BL	R FOR	583 12.0 Sm	631 9.2 Eb	621 13.0 An	603 5.0 Bl
616 7.7 Wf	*022426*	583 11.7 En	631 9.3 Bw	621 13.0 Lg	605 5.2 Ht
617 7.6 L	582 10.1 Bl	586 11.8 Ht	634 9.8 Lg	624 13.1 L	611 4.9 Dr
619 7.8 Ah	586 9.7 Bl	592 11.6 En	638 9.4 Wy	627 13.0 Pt	612 5.4 Ht
620 7.5 BL	596 9.4 Bl	593 11.2 Ht	639 9.9 Al	633 13.1 L	612 5.0 Bl
621 8.2 An	603 9.0 Bl	596 10.6 Bl	646 10.6 Bw	640 13.5 Lg	615 4.8 Dr
621 8.2 Ch	612 9.0 Bl	602 11.2 En	650 10.5 B	RX TAU	619 4.8 Dr
621 8.0 Ah	U CET	603 10.4 Bl	658 11.5 Al	043208	623 4.9 Dr
622 7.7 BL	*022813*	609 10.1 Dr	659 11.6 Bw	617 12.0 L	627 4.8 Dr
622 7.9 Ah	615 12.8 Ch	612 9.8 Bl	T FOR	627 12.8 L	R CAE
624 7.9 Wf	633 11.9 Sb	612 10.3 Ht	*032528*	627 12.5 Pt	*043738*
624 8.0 Ah	640 12.5 Pt	615 9.8 Dw	617 8.8 L	631 12.5 Sf	582 11.9 Ht
624 8.0 BL	651 12.1 Sb	615 9.0 Dr	624 8.9 L	640 13.0 Sf	582 11.7 Sm
626 8.0 BL	RR CEP	619 8.8 Dr	630 9.0 L	641 12.8 L	582 11.9 Bl
627 7.8 Pt	022980	623 8.6 Dr	641 9.5 L	653[13.0 Wn	583 11.7 En
627 8.0 L	615 11.7 L	627 8.2 Dr	U CAM	R RET	586 11.9 Ht
632 8.2 BL	627 11.9 L	631 7.9 Dr	033362	*043263*	589 12.0 Sm
633 8.3 Ah	631 12.1 Sf	641 7.6 Dw	654 11.7 Wn	582 10.0 En	593 12.0 Ht
635 8.6 BL	640 12.2 Sf	T HOR	U ERI	582 9.7 Bl	593 11.8 En
638 8.7 BL	640 12.0 Pt	*025751*	*034625*	582 9.8 Ht	596 11.8 Bl
639 8.1 Jo	641 12.3 L	596 12.4 Bl	611 11.0 Dr	583 9.9 Sm	603 12.0 Bl
639 7.8 Al	647 12.7 Sf	603 11.9 Bl	619 11.2 Dr	586 10.4 Ht	611 12.0 Dr
640 8.8 BL	R TRI	612 11.3 Ht	627 11.6 Dr	590 10.1 Sm	612 12.0 Bl
640 9.0 Lg	023133	612 11.5 Bl	T ERI	592 10.1 En	619 12.4 Dr
641 8.4 L	619 11.4 Ah	615 11.2 Dr	*035124*	593 10.4 Ht	627 13.0 Dr
641 9.0 Ah	621 11.0 Ah	619 11.1 Dr	611 11.6 Dr	596 10.5 Bl	R PIC
642 9.1 An	621 10.2 Wd	627 10.8 Dr	619 11.5 Dr	603 10.4 Bl	*044349*
643 8.9 Ah	622 11.0 Ah	U ARI	627 10.7 Dr	605 11.0 Ht	582 9.0 Ht
645 8.8 BL	624 11.0 Ah	030514	631 10.9 Dr	611 11.1 Dr	582 9.0 Sm
646 8.0 Jo	626 10.5 B	644 13.9 B	W ERI	612 11.4 Ht	582 8.8 Bl
647 9.0 BL	627 10.2 Pt	X CET	*040725*	612 10.9 Bl	583 9.0 En
651 9.0 BL	631 10.3 Sf	*031401*	609 8.7 Dr	615 11.2 Dr	586 8.8 Ht
653 9.1 BL	638 10.0 Sf	617 9.1 L	615 8.6 Dr	619 11.5 Dr	589 8.4 Sm
654 8.8 Jo	641 9.6 Ah	622 9.0 Wy	619 8.5 Dr	623 11.5 Dr	592 8.6 En
655 9.1 BL	642 9.5 Ah	623 9.5 An	623 8.6 Dr	631 11.7 Dr	593 7.9 Ht
657 9.1 BL	643 9.3 Ah	627 8.9 Pt	631 8.7 Dr		596 7.6 Bl
661 9.1 BL	646 9.4 Sf				603 7.3 Bl

Variable Star Observations Received During February, 1929.

J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
R Pic			**S Pic**			**T Col**			**T Ori**			**U Aur**			**SU Tau**		
044349			*050848*			*051533*			*053005a*			053531			054319		
609	7.5	Dr	592	11.4	En	621	10.1	Lg	628	10.9	L	627	8.5	Pt	647	10.5	Pt
612	7.2	Bl	596	11.4	Bl	623	9.9	Dr	630	11.1	L	631	8.5	Eb	652	10.1	Pt
615	7.6	Dr	603	11.3	Bl	624	9.9	Lg	630	10.7	Wy	631	8.7	Kz	653	10.1	Pt
619	7.5	Dr	612	11.3	Bl	627	10.0	Dr	631	10.9	L	632	9.0	Sf	653	10.1	Sf
621	7.5	Dr	**R Aur**			631	9.3	Dr	632	11.0	L	633	9.0	Ah	654	10.1	Pt
627	7.6	Dr	050953			637	9.5	Lg	633	10.9	L	640	9.0	Ah	**S Col**		
631	7.6	Dr	619	10.3	Ch	**S Aur**			633	11.4	Gi	641	9.0	Ah	*054331*		
V Tau			619	9.8	Ah	052034			638	10.6	Pt	642	9.0	Ah	582	9.3	Ht
044617			622	9.8	Ah	616	11.4	Ch	638	11.3	L	643	9.2	Ah	582	8.7	Sm
621	9.5	Lg	624	9.6	Ah	623	11.5	An	640	10.7	L	650	9.3	Sf	582	9.0	Bl
627	9.8	Pt	627	9.3	Pt	624	11.0	Wy	640	10.8	Pt	**Y Tau**			583	9.6	En
631	10.3	Eb	631	9.9	Kz	627	9.6	Pt	642	10.5	Wy	053920			586	9.6	Ht
631	10.2	Kz	632	9.7	Eb	631	10.8	Eb	642	10.2	An	602	9.8	Ch	589	8.6	Sm
632	10.6	Wy	632	10.6	Wy	631	10.7	Kz	644	10.5	Pt	609	9.8	Ch	592	9.3	En
634	10.4	Lg	633	9.8	Ah	646	9.8	Jo	645	10.5	Pt	619	9.8	Ch	593	9.9	Ht
642	12.3	Wy	640	9.5	Ah	654	9.9	Jo	646	10.5	Pt	**SU Tau**			598	9.4	Bl
R Ori			641	9.6	Ah	**W Aur**			647	10.5	Pt	054319			603	9.5	Bl
045307			642	9.7	Ah	052036			648	9.8	Gi	613	10.4	L	612	9.5	Bl
624	10.0	L	642	10.5	Wy	615	9.4	L	653	9.8	Pt	615	10.2	L	**Z Tau**		
631	10.7	Kz	642	9.1	Al	616	9.9	Ch	654	9.7	Pt	617	10.0	L	054615a		
631	10.7	Eb	643	9.5	Ah	623	9.4	An	**AN Ori**			621	9.9	L	631	9.7	Sf
633	10.3	L	658	9.1	Al	625	9.4	L	*053005f*			621	9.4	Lg	638	10.2	Sf
R Lep			**T Pic**			627	9.9	Pt	613	11.6	L	621	10.1	An	653	10.7	Sf
045514			*051247*			631	9.9	Eb	615	11.6	L	622	10.1	An	**RU Tau**		
619	8.2	Ch	582	11.7	Ht	631	9.6	Kz	617	11.8	L	622	9.5	Lg	054615c		
620	8.5	An	582	11.4	Sm	632	10.0	Sf	621	11.5	L	622	9.8	B	631	12.8	Sf
624	7.6	L	583	11.6	En	638	10.1	Sf	624	11.7	L	622	9.6	Lg	**R Col**		
627	6.8	Pt	586	11.8	Ht	646	9.8	Jo	625	11.6	L	623	9.7	L	*054629*		
631	9.1	Sb	586	11.4	Bl	650	10.8	Sf	627	11.7	L	623	10.1	An	582	10.3	Ht
633	7.7	L	589	11.0	Sm	654	9.9	Jo	628	11.6	L	624	9.8	B	582	10.6	Sm
637	9.3	Sb	590	11.1	Bl	**S Ori**			630	11.6	L	625	9.6	Pt	582	10.2	Bl
638	8.2	Jo	592	11.2	En	*052404*			631	11.6	L	625	9.4	Lg	583	10.3	En
641	8.2	B	593	11.5	Ht	620	11.2	An	632	11.7	L	627	9.6	Pt	586	9.8	Ht
646	7.5	Jo	598	10.2	Bl	624	10.8	Wy	633	11.6	L	627	9.8	L	589	9.9	Sm
646	9.6	Sb	603	10.0	Bl	625	10.0	B	638	11.6	L	629	9.8	L	592	10.0	En
647	7.5	Al	611	9.6	Dr	627	10.4	Pt	640	11.6	L	630	9.8	L	593	9.6	Ht
650	9.4	Sb	612	9.7	Bl	637	10.4	Wy	**S Cam**			630	9.5	Lg	598	9.7	Bl
654	9.2	Sb	619	8.9	Dr	642	9.8	Al	063068			631	9.8	L	603	9.6	Bl
654	7.5	Jo	621	8.8	Dr	646	9.0	Jo	624	8.6	Wy	631	10.1	Sf	609	9.1	Dr
V Ori			627	8.7	Dr	654	8.8	Jo	627	8.4	Pt	632	9.8	L	612	9.4	Bl
050003			631	8.5	Dr	**T Ori**			639	8.9	Wy	632	10.3	Wy	615	9.2	Dr
621	13.8	Lg	**Nov Tau**			*053005a*			642	9.2	Ah	633	9.8	L	619	9.1	Dr
624	14.1	B	051316			613	10.9	L	643	9.0	Ah	634	9.6	Lg	623	9.5	Dr
652	13.4	Pt	624	13.3	L	615	11.2	L	**RR Tau**			637	9.7	Lg	631	9.4	Dr
T Lep			641	13.2	L	617	10.3	L	053326			638	9.9	Pt	**α Ori**		
050022			**T Col**			617	10.2	An	626	12.6	B	638	10.3	L	054907		
582	9.6	Bl	*051533*			620	10.8	An	**RU Aur**			638	10.1	Sf	617	0.4	L
596	9.0	Bl	582	11.7	Ht	621	10.2	An	053337			639	9.4	Lg	627	0.7	L
603	8.8	Bl	582	11.8	Bl	621	10.2	L	622	13.7	Lg	640	9.5	Lg	633	0.6	L
612	8.6	Bl	586	11.7	Ht	622	10.3	An	627	12.5	Pt	640	10.1	Pt	**U Ori**		
627	8.6	Pt	589	11.9	Sm	623	10.1	An	637	13.3	Lg	640	10.0	L	054920a		
641	8.6	B	592	11.9	En	624	10.7	Wy	640	13.4	Sf	641	9.5	Lg	613	8.3	Ah
S Pic			593	11.6	Ht	624	10.3	L	**U Aur**			642	10.1	Sf	619	8.4	Ah
050848			598	11.6	Bl	625	10.2	L	053531			644	10.0	Pt	621	8.5	Ah
582	10.6	Sm	603	11.4	Bl	625	10.5	Pt	616	9.0	Ch	644	9.9	B	622	8.6	Ah
582	10.7	Bl	611	10.8	Dr	626	10.7	B	619	9.1	Ah	645	9.9	Cl	624	8.7	Ah
583	11.0	En	612	11.2	Bl	627	10.7	L	622	9.1	Ah	645	10.2	Pt	627	8.2	Pt
589	11.4	Sm	619	10.4	Dr	627	10.6	Pt	624	9.1	Ah	646	10.0	Pt	629	8.6	Ah

VARIABLE STAR OBSERVATIONS RECEIVED DURING FEBRUARY, 1929.

J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.
U ORI	R OCT	S LYN	R GEM	RR MON	U CMI
054920a	*055686*	063558	070122a	071201	073508
630 8.5 Ah	593 12.0 En	631 11.8 Sf	633 7.7 Ah	633 13.1 L	622 12.6 An
631 8.6 Wd	598 12.2 Bl	640 11.3 Sf	633 7.0 Al	640 12.9 Lg	623 12.3 L
631 8.5 Kz	615 12.6 Dr	652 10.2 Pt	639 7.6 Al	640 12.8 Sf	633 12.8 L
631 8.8 Eb	628 12.3 Dr	653 10.8 Sf	639 7.7 Jo	648 12.4 Gi	640 12.6 Pt
633 8.8 Ah	X AUR	X GEM	640 7.8 Ah	653 11.7 Sf	644 12.9 B
640 8.8 Ah	060450	064030	641 7.8 Ah	V GEM	S GEM
641 8.8 Ah	602 9.7 Ch	622 11.3 B	642 7.8 Ah	071713	073723
642 8.8 Ah	611 10.8 Ch	624 11.3 Wy	643 7.9 Ah	619 9.0 Ah	644 13.1 B
642 8.6 Fd	616 10.5 Ch	624 11.3 Bn	646 7.8 Jo	621 8.7 Ah	648 13.6 Gi
642 8.5 Al	619 11.4 Ch	628 11.5 Bn	647 7.7 Al	622 8.5 Ah	W PUP
643 8.8 Ah	622 11.2 B	631 11.9 Bw	650 7.7 B	623 9.1 Lg	*074241*
648 8.6 Gb	626 11.4 B	645 12.7 Bw	654 7.7 Jo	624 8.6 Ah	582 8.7 En
654 8.6 Rw	633 11.9 Al	659 12.8 Bw	Z GEM	633 9.1 Ah	582 8.8 Ht
UW ORI	640 12.0 Pt	W MON	070122b	633 9.8 Gi	582 8.8 Sm
054920b	641 11.9 B	*064707*	604 7.5 Ch	637 8.6 Lg	582 8.5 Bl
602 7.1 Ch	647 12.5 Al	640 9.5 Pt	626 7.6 Ch	640 9.0 Pt	586 9.1 Ht
609 7.3 Ch	V AUR	641 10.3 B	631 8.2 Kz	641 9.4 Ah	589 9.1 En
619 7.5 Ch	061647	Y MON	631 8.4 Eb	642 9.4 Ah	589 9.0 Sm
631 10.5 Kz	615 11.8 L	065111	640 12.5 Pt	642 9.5 B	593 9.6 Ht
631 10.6 Eb	622 12.0 Lg	613 10.7 Ch	650 12.4 B	643 9.5 Ah	598 10.1 Sm
V CAM	625 11.4 L	622 11.0 Lg	TW GEM	648 9.6 Gi	598 10.2 Bl
054974	626 11.6 B	622 10.4 B	070122c	S CMI	603 10.7 Bl
622 11.4 B	V MON	639 10.5 Lg	640 8.0 Pt	072708	612 11.5 Bl
627 11.7 Pt	*061702*	640 10.0 Pt	R CMI	610 8.0 Ch	T GEM
631 11.8 Sf	613 9.6 Ch	X MON	070310	625 8.3 Lg	074323
638 12.1 Sf	642 10.7 Al	*065208*	619 9.6 Ch	626 8.7 Ch	624 12.9 Wy
647 12.2 Sf	AG AUR	613 8.3 Ch	621 9.4 Lg	632 8.8 Wy	644 11.0 B
Z AUR	062047	620 7.8 By	622 9.8 An	633 8.8 Al	647 10.7 Bw
055353	615 9.6 L	621 7.8 By	623 9.7 L	637 8.5 Lg	659 9.8 Bw
613 10.7 Ch	625 10.3 L	624 7.7 L	633 9.9 L	639 9.0 Jo	U PUP
617 12.6 By	632 10.2 L	625 7.7 By	634 9.7 Lg	640 9.2 Pt	*075612*
619 10.7 Ch	U LYN	627 7.7 By	640 10.8 Ah	641 9.5 Wy	641 13.6 Lg
620 10.6 By	063159	633 7.3 L	641 10.6 Ah	641 9.5 B	644 13.3 B
621 10.6 By	622 11.7 B	640 7.2 By	641 10.0 B	642 9.4 Fd	659 13.2 Bw
625 10.7 By	R MON	641 7.3 By	R VOL	646 9.5 Jo	R CNC
625 10.7 Pt	063308	643 7.4 By	*070772*	647 9.6 Al	081112
626 10.7 By	621 12.2 Lg	V CMI	582 12.0 Ht	647 9.8 BL	612 10.4 Ch
626 10.4 B	622 11.8 Lg	070109	583 11.8 Sm	651 9.9 BL	641 10.1 Ah
627 10.7 By	623 12.3 Lg	619 12.4 Ch	583 12.6 En	653 10.0 BL	642 10.0 Ah
627 10.6 Pt	625 12.4 Lg	621 12.5 Lg	586 12.2 Ht	655 10.1 BL	642 9.8 B
628 10.7 By	639 11.5 Lg	623 12.9 L	593 13.0 En	657 10.0 BL	644 9.8 Pt
638 10.9 Pt	640 11.6 Lg	633 13.1 L	593 12.6 Ht	659 10.1 BL	V CNC
640 10.9 Pt	640 11.5 Pt	634 12.6 Lg	594 12.6 Sm	660 10.0 BL	081617
640 10.9 By	641 11.7 B	640 13.7 Sf	615 12.3 Dr	T CMI	612 11.0 Ch
641 11.0 By	641 11.7 Lg	644 13.8 B	621 12.4 Dr	072811	617 11.5 By
642 10.5 Al	NOV PIC	654 13.3 Wn	631 12.6 Dr	623 11.3 Lg	620 11.9 By
643 11.0 By	*063462*	R GEM	L_2 PUP	639 11.2 Lg	621 12.1 By
644 10.8 Pt	582 7.4 En	070122a	*071044*	640 10.8 Pt	621 11.3 Ah
645 10.9 Pt	582 7.2 Ht	613 7.5 Ah	611 4.4 Dr	641 11.1 B	622 11.3 Ah
646 10.9 Pt	582 7.5 Sm	619 7.5 Ah	615 4.3 Dr	S VOL	624 11.5 Ah
647 10.9 Pt	586 7.4 Sm	621 7.6 Ah	619 4.2 Dr	*073173*	625 12.0 By
652 10.9 Pt	586 7.2 Ht	622 7.9 Ah	623 4.2 Dr	582 13.5 Bl	627 12.0 By
653 10.7 Pt	589 7.4 Sm	624 7.8 Ah	628 4.2 Dr	583 12.2 En	628 12.0 By
654 10.7 Pt	593 7.5 En	628 7.7 Ah	631 4.5 Dr	593 12.2 En	642 12.2 B
R OCT	593 7.2 Ht	630 7.7 Ah	RR MON	594 13.2 Sm	643 12.3 By
055686	594 7.5 Sm	631 7.5 Eb	071201	615 12.6 Dr	644 12.4 Pt
582 12.2 Bl	597 7.5 En	631 7.7 Kz	624 13.9 L	619 12.5 Dr	
583 12.5 En		631 7.9 Wd	631 13.0 Sf	628 12.2 Dr	

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J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.
RT HYA	RX UMA	R LEO	S CAR	V HYA	T CVN
082405	090567	094211	*100661*	*104620*	122532
644 8.2 Pt	613 11.6 L	617 9.2 An	623 7.0 Dr	590 7.5 Bl	644 9.3 Pt
650 8.4 B	625 11.0 L	619 9.0 An	628 6.9 Dr	612 8.0 Bl	Y VIR
R CHA	633 10.6 L	621 8.9 Ah	631 6.7 Dr	617 7.5 L	*122803*
082476	RW CAR	622 8.9 Ah	Z CAR	627 7.1 L	617 13.4 L
582 12.0 En	*091868*	624 8.9 Ah	*101058a*	633 7.1 L	627 13.5 L
582 12.1 Sm	590 12.6 Bl	630 9.0 Ah	586 10.7 Sm	644 6.7 Pt	633 13.4 L
582 12.0 Bl	615 13.2 Dr	633 8.3 Al	590 10.8 Bl	RS HYA	U CEN
589 11.7 Sm	628 13.5 Dr	640 9.4 Ah	593 11.0 En	*104628*	*122854*
593 11.6 En	Y VEL	641 9.2 Ah	598 11.0 Sm	590 13.5 Bl	590 10.9 Bl
598 11.5 Sm	092551	642 9.1 Ah	603 11.1 Bl	RS CAR	603 10.4 Bl
603 11.1 Bl	586[12.4 Sm	642 9.3 Fd	611 11.1 Dr	*110361*	612 10.1 Bl
612 10.6 Bl	590[12.9 Bl	643 9.1 Ah	612 11.3 Bl	593[12.3 En	T UMA
U CNC	615[13.2 Dr	644 8.8 Pt	619 11.5 Dr	598[12.3 Sm	123160
083019	628[13.2 Dr	645 9.7 Wd	628 11.7 Dr	RY CAR	604 6.5 Ch
642 12.8 B	R CAR	646 8.7 Al	AF CAR	*111561*	613 6.6 Ah
645 12.6 Bw	*092962*	646 9.0 Jo	*101058b*	590[13.1 Bl	613 6.5 Kl
654 11.8 Sf	582 8.0 Ht	654 9.6 Jo	615 13.0 Dr	615[13.4 Dr	615 6.4 Kl
659 11.9 Bw	582 8.0 Bl	654 10.0 Rw	628[12.8 Dr	619[13.5 Dr	619 6.8 Ah
X UMA	583 8.0 En	659 9.8 BL	W VEL	623[13.6 Dr	620 6.3 Kl
083350	583 8.0 Sm	660 9.8 BL	*101153*	628[13.5 Dr	621 6.8 Ah
632[11.9 Wy	586 8.2 Ht	661 10.0 BL	586 12.0 Sm	RS CEN	622 6.7 Ah
637[13.0 Lg	589 7.6 En	Y HYA	603 11.6 Bl	*111661*	623 6.4 Kl
642[13.5 B	590 7.6 Sm	*094622*	612 11.6 Bl	586 12.1 Sm	624 6.8 Ah
S HYA	593 7.0 Ht	644 6.3 Pt	U HYA	590 12.5 Bl	625 6.6 Kl
084803	602 6.9 En	Z VEL	*103212*	611 13.0 Dr	628 6.9 Ah
639 13.1 Lg	603 7.0 Bl	*094953*	615 5.3 L	615 13.2 Dr	629 6.8 Ah
642 12.7 B	609 6.5 Dr	586[12.8 Ht	623 5.3 L	619 13.3 Dr	630 6.9 Ah
644 13.3 Pt	612 6.8 Bl	590 13.1 Bl	629 5.3 L	621 13.3 Dr	633 6.9 Ah
T HYA	612 6.7 En	594[12.8 Sm	640 4.8 L	623 13.3 Dr	639 6.9 Lg
085008	615 6.4 Dr	615 13.3 Dr	RZ CAR	628 13.2 Dr	640 6.9 Ah
613 10.4 Ch	619 6.2 Dr	628 13.6 Dr	*103270*	631 12.9 Dr	641 7.1 Ah
623 11.9 L	623 5.8 Dr	V LEO	615 14.0 Dr	X CEN	642 7.1 Ah
633 11.7 L	628 5.5 Dr	095421	619 14.0 Dr	*111441*	642 7.4 Al
639 12.2 Lg	631 5.0 Dr	644 12.6 Pt	623 13.9 Dr	590 7.9 Bl	642 7.2 Fd
642 12.0 B	X HYA	RV CAR	628 13.8 Dr	611 7.3 Dr	643 7.2 Ah
T CNC	*093014*	*095563*	631 13.5 Dr	612 7.2 Bl	644 7.1 Pt
085120	641 13.1 Lg	590[13.1 Bl	R UMA	615 7.3 Dr	644 6.9 Kl
613 8.8 Ch	Y DRA	615[13.3 Dr	103769	628 7.3 Dr	645 7.5 Wd
632 8.8 Wy	093178	628[13.7 Dr	613 11.5 Ah	W CEN	646 7.3 Kl
644 8.0 Pt	613 8.5 L	S CAR	619 11.2 Ah	*115058*	646 7.0 Jo
646 9.9 B	625 9.1 L	*100661*	621 11.2 Ah	590 13.3 Bl	649 7.5 Kl
T PYX	633 9.1 L	582 9.6 Sm	622 10 9 Ah	SU VIR	654 7.5 Jo
090031	641 9.8 Lg	582 9.2 Bl	623 10.8 Ch	120012	R VIR
590 [w Bl	653 10.3 Bw	586 9.8 Ht	624 10.5 Ah	644 10.5 Pt	123307
V UMA	R LMI	589 9.6 Sm	630 9.5 Ah	T VIR	643 10.0 Ah
090151	093934	590 9.4 Bl	633 8.9 Ah	*120905*	644 9.7 Pt
613 11.0 L	612 12.8 Ch	593 9.5 En	633 8.4 Al	644 9.2 Pt	RS UMA
625 10.8 L	641 11.4 Ah	593 9.6 Ht	639 8.5 Jo	R CRV	123459
633 10.7 L	642 11.3 Ah	598 9.2 Sm	640 8.5 Ah	*121418*	604 11.6 Ch
642 10.3 B	642 10.6 Fd	602 9.2 En	641 8.2 Ah	617 8.8 L	639 12.1 Lg
W CNC	644 11.0 Pt	603 9.5 Bl	642 8.1 Ah	627 8.2 L	644 13.4 Pt
090425	RR HYA	609 8.3 Dr	642 8.4 Fd	633 7.9 L	S UMA
613 14.0 L	*094023*	611 8.2 Dr	643 8.0 Al	644 7.5 Pt	123961
625 14.3 L	615[13.5 Dr	612 8.7 En	644 8.3 Pt	SS VIR	613 8.5 Kl
633 14.0 L	628 13.5 Dr	612 7.8 Bl	645 8.5 Wd	*122001*	613 8.0 Ah
642 13.4 B	R LEO	615 7.8 Dr	646 7.8 Al	617 7.7 L	615 8.3 Kl
	094211	619 7.7 Dr	646 7.9 Jo	627 8.0 L	617 7.6 An
	612 8.8 Ch	620 7.7 Dw	654 7.7 Jo	633 8.1 L	619 8.0 Ah

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J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
S UMA			**U OCT**			**Z VIR**			**V LIB**			**W LIB**			**R LIB**		
123961			*131283*			*140512*			*143417*			*153215*			*154715*		
620	8.3	Kl	612	12.4	Ht	619	10.4	Dr	613[	13.1	L	624[	13.4	L	619[	11.0	L
621	7.7	Ah	615	12.1	Dr	628	11.0	Dr	624	13.3	L	632[	14.3	L	624	14.0	L
622	7.8	Ah	628	12.9	Dr	**RU HYA**			632	12.6	L	**S UMI**			632	14.3	L
623	8.3	Kl	**V VIR**			*140528*			**Y LUP**			153378			**R LUP**		
624	7.6	Ah	*132202*			590	9.0	Bl	*145254*			610	9.6	Ch	*154736*		
625	8.3	Kl	617[	13.2	L	**R CEN**			590	13.2	Bl	630	9.9	Lj	619[	13.2	Dr
625	8.0	Ch	627[	13.7	L	*140959*			619	14.0	Dr	631	10.0	Lj	631	13.5	Dr
627	8.0	Lj	**R HYA**			590	10.5	Bl	628	14.1	Dr	640	10.1	Lj	**RR LIB**		
628	7.7	Ah	*132422*			612	9.9	Bl	**S APS**			640	9.5	Ah	*155018*		
629	7.7	Ah	590	5.3	Bl	619	7.6	Dr	*145971*			641	9.7	Lg	619[	13.1	L
630	7.7	Ah	617	5.9	L	623	7.4	Dr	581[	12.5	Bl	641	9.6	Ah	624[	14.0	L
631	8.0	Lj	627	6.4	L	628	7.1	Dr	582[	11.9	En	643	9.6	Ah	632[	14.0	L
633	7.6	Ah	633	6.6	L	631	7.1	Dr	590[	13.4	Bl	643	10.2	Lj	**RZ SCO**		
639	7.6	Jo	644	6.5	Pt	631	7.5	Dr	603[	12.5	Bl	644	9.3	Pt	*155823*		
639	7.2	Lg	**S VIR**			**U UMI**			612[	13.4	Bl	648	9.5	Al	647	8.5	Pt
640	7.8	Lj	*132706*			141567			**RT LIB**			**T NOR**			**Z SCO**		
640	8.0	Ah	604	12.4	Ch	613	11.5	Ah	*150018*			*153654*			*160021*		
641	7.8	Ah	644	12.6	Pt	621	11.5	Ah	644	8.9	Pt	619	11.8	Dr	622	11.1	L
642	7.9	Ah	**RV CEN**			624	11.8	Ah	**T LIB**			628	10.6	Dr	632	11.2	L
642	7.5	Al	*133155*			627	11.7	Lj	*150519*			631	10.0	Dr	**R HER**		
642	7.8	An	590	9.5	Bl	631	11.7	Lj	644	13.2	Pt	**R CRB**			160118		
642	7.6	Fd	603	8.8	Bl	644	11.8	Pt	**Y LIB**			154428			647	13.7	Pt
643	7.9	Ah	612	9.1	Bl	645	11.7	Cl	*150605*			613	6.0	L	**U SER**		
643	7.8	Lj	615	8.9	Dw	**S BOO**			613	12.0	L	615	6.0	L	160210		
644	8.0	Pt	615	9.1	Dr	141954			624	12.3	L	617	6.0	L	647	8.6	Pt
644	8.5	Kl	628	8.8	Dr	621	12.9	L	632	12.4	L	619	6.0	L	**SX HER**		
645	8.5	Wd	**T UMI**			629	12.9	L	644	12.2	Pt	621	6.0	L	160325		
646	7.8	Jo	133273			638	12.3	L	**S LIB**			624	6.0	L	615	8.5	L
646	8.5	Kl	629[	12.9	L	644	12.0	Pt	*151520*			625	6.0	L	625	8.7	L
649	8.5	Kl	640	13.6	L	**RS VIR**			613	12.2	L	627	6.1	L	638	8.7	L
654	8.4	Jo	**T CEN**			142205			624	11.7	L	627	6.1	Lj	644	8.2	Pt
RU VIR			*133633*			617	8.7	L	632	10.8	L	629	6.1	L	647	8.1	Pt
124204			590	6.0	Bl	627	9.0	L	644	9.2	Pt	630	6.0	L	652	8.5	Pt
617	11.0	L	615	6.8	Dr	633	9.7	L	**S SER**			630	6.1	Pt	654	8.7	Pt
627	11.1	L	619	6.1	Dr	**V BOO**			151714			631	6.1	Lj	**RU HER**		
633	11.3	L	627	7.1	Dr	142539a			621	11.9	L	631	6.0	L	160625a		
U VIR			628	7.0	Dr	640	9.5	Ah	629	11.9	L	632	6.0	L	614	12.0	L
124606			631	7.4	Dr	641	9.4	Ah	638	12.6	L	632	6.1	Pt	625	12.3	L
617	12.5	L	**RT CEN**			642	9.3	Ah	**S CRB**			633	6.0	L	638	12.5	L
627	12.9	L	*134236*			643	9.4	Ah	151731			638	6.0	L	647	13.0	Pt
633	13.2	L	590	12.2	Bl	644	8.9	Pt	604	7.4	Ch	640	6.1	L	**R SCO**		
RV VIR			619	12.1	Dr	648	9.5	Gb	644	8.4	Pt	640	5.9	Ah	*161122a*		
130212			628	11.9	Dr	**R CAM**			**RS LIB**			643	6.1	Ah	647	9.9	Pt
617	14.5	L	**R CVN**			142584			*151822*			644	6.1	Pt	**S SCO**		
627	14.4	L	134440			604	10.4	Ch	613	7.8	L	647	6.0	Pt	*161122b*		
633	14.5	L	641	10.6	Ah	626	9.4	By	624	8.3	L	652	6.1	Pt	647	12.0	Pt
U OCT			643	10.4	Ah	627	9.4	Py	632	8.8	L	653	6.0	Gb	**W CRB**		
131283			644	10.4	Pt	628	9.3	By	**RU LIB**			654	6.1	Pt	161138		
582	10.4	Ht	**RX CEN**			640	8.9	By	*152714*			**X CRB**			647	10.8	Pt
583	10.4	En	*134536*			641	8.9	By	613	13.5	L	154536			**W OPH**		
583	10.5	Sm	590[	12.5	B	643	8.9	By	624	13.5	L	644	10.0	Pt	*161607*		
586	10.7	Ht	**T APS**			**R BOO**			632	13.3	L	**R SER**			621[	14.1	L
590	10.9	Bl	*134677*			143227			**R NOR**			154615			629[	13.0	L
590	11.2	Sm	583[	12.3	En	627	12.4	Lj	*152849*			604	7.9	Ch	640[	12.3	L
593	11.0	En	590[	13.2	Bl	631	12.4	Lj	619	12.4	Dr	644	7.8	Pt	**V OPH**		
593	11.1	Ht	619	12.9	Dr	644	12.2	Pt	628	12.4	Dr	**V CRB**			*162112*		
603	11.5	Bl	628	12.5	Dr							154639			621	8.0	L
612	12.0	Bl										644	9.0	Pt	629	8.4	L

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J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.
V OPH	RR SCO	R PAV	R SCT	SW SGR	RU SGR
162112	*165030a*	*180363*	*184205*	*191331*	*195142*
638 8.0 L	631 6.4 Dr	582[11.9 Sm	652 5.6 Pt	584 11.5 Bl	598 7.6 Sm
647 7.8 Pt	SS OPH	593[11.9 En	654 5.6 Pt	592 10.7 Bl	603 7.9 Bl
U HER	165202	619 11.3 Dr	NOV AQL	TZ CYG	612 7.7 Bl
162119	647 11.5 Pt	631 10.9 Dr	184300	191350	NOV CYG
604 9.3 Ch	RV HER	T HER	652 11.7 Pt	624 9.8 Pt	195553
647 10.0 Pt	165631	180531	S CRA	U LYR	625[12.2 Pt
SS HER	615 13.7 L	615 12.6 L	*185437a*	191637	640[12.4 Pt
162807	629 11.6 L	629 11.8 L	585 12.1 Bl	654 10.0 Pt	652[12.2 Pt
615 11.2 L	638 10.5 L	640 10.8 L	R CRA	R CYG	Z CYG
627 11.7 L	647 10.4 Pt	652 9.1 L	*185537a*	193449	195849
638 11.4 L	RT HER	W DRA	585 11.7 Bl	625 13.2 Pt	610 9.8 Ch
647 10.3 Pt	170627	180865	T CRA	T PAV	625 10.6 Pt
T OPH	615 13.8 L	629 11.4 L	*185537b*	*193972*	S TEL
162815	629 13.8 L	640 12.0 L	585[12.5 Bl	582 12.1 En	*195855*
621[12.5 L	640 13.4 L	652 12.6 Pt	Z LYR	582 12.4 Ht	585 13.2 Bl
629[12.0 L	Z OPH	X DRA	185634	582 12.3 Sm	SY AQL
640 12.7 L	171401	180666	623 10.0 L	582 12.0 Bl	200212
S OPH	652 10.5 Pt	629 11.7 L	632 10.3 L	586 12.7 Ht	624 9.5 L
162816	RS HER	640 13.4 L	652 10.6 Pt	589 12.7 Sm	BU CYG
629 13.4 L	171723	NOV OPH	RT LYR	592 12.4 Bl	200250
W HER	652 9.0 Pt	180911	185737	593 12.6 En	623 12.4 Lj
163137	S OCT	652[12.0 Pt	632 13.9 L	619 13.7 Dr	625 12.4 Lj
647 12.6 Pt	*172486*	TV HER	R AQL	631 13.6 Dr	S AQL
R DRA	583[12.1 En	181031	190108	RT CYG	200715a
163266	585[13.0 Bl	615[13.0 L	652 10.0 Pt	194048	625 10.4 Pt
613 7.9 Ah	586[13.0 Ht	629[13.3 L	V LYR	609 7.7 Ch	RW AQL
619 8.0 Ah	594[12.1 Sm	640[13.3 L	190529a	613 8.6 Ah	200715b
621 8.0 Ah	612[12.8 Ht	RY OPH	623[13.8 L	619 8.6 Ah	625 9.4 Pt
622 8.2 Ah	619 13.5 Dr	181103	S LYR	621 8.7 Ah	R TEL
623 8.2 Lj	631[13.3 Dr	652 7.8 Pt	190925	622 8.6 Ah	*200747*
624 8.3 Ah	RU OPH	W LYR	623[12.6 Wy	624 8.8 Ah	582 9.1 Bl
628 8.5 Ah	172809	181136	X LYR	625 8.0 Pt	592 9.3 Bl
630 8.7 Ah	630 11.9 L	652 7.8 Pt	190926	633 8.9 Ah	603 9.4 Bl
630 8.7 Lj	638 11.1 L	RV SGR	652 10.6 Pt	641 9.3 Ah	612 9.8 Bl
631 8.8 Lj	652 9.3 Pt	*182133*	RS LYR	643 9.6 Ah	RU AQL
633 9.3 Ah	RT SER	582 12.4 Bl	190933a	TU CYG	200812
640 9.3 Ah	*173212*	SV HER	631[14.0 L	194348	624[12.3 L
641 9.4 Ah	630 12.4 L	182224	RU LYR	609 12.6 Ch	W CAP
641 9.4 Lj	RU SCO	621 11.0 L	190941	χ CYG	*200822*
643 9.4 Ah	*173543*	630 11.5 L	623 10.4 L	194632	586 12.3 Bl
647 10.1 Pt	582 10.2 Bl	640 12.1 L	632 10.6 L	625 13.1 Pt	RS CYG
654 9.8 Jo	W PAV	652 13.0 Pt	U DRA	S PAV	200938
RR OPH	*174152*	SV DRA	190967	*194659*	609 7.0 Ch
164319	585[13.0 Bl	183149	611 9.4 Ch	582 8.8 En	610 7.0 Ch
627 8.7 L	593[12.1 En	630 13.8 L	621 9.5 Ch	592 8.7 En	611 7.0 Ch
638 8.6 L	RS OPH	RZ HER	623 9.6 L	RR SGR	621 7.2 Ch
647 8.6 Pt	174406	183225	632 9.7 L	*194929*	624 7.6 L
S HER	652 11.1 Pt	631 12.7 L	RY SGR	585 12.8 Bl	625 7.6 Ch
164715	RT OPH	X OPH	*191033*	RU SGR	625 7.0 Pt
647 10.6 Pt	175111	183308	582 6.5 En	*195142*	632 8.1 Sb
RS SCO	623 10.5 L	622 8.5 L	582 6.5 Ht	582 8.0 En	633 7.4 L
164844	640 11.3 L	632 8.8 L	584 6.0 Bl	582 7.6 Ht	R DEL
584 8.5 Bl	652 11.6 Pt	652 8.8 Pt	586 6.5 Ht	582 7.8 Sm	201008
619 9.8 Dr	RU HER	R SCT	592 6.0 Bl	585 7.8 Bl	625 13.5 Pt
631 10.5 Dr	175519	*184205*	TY SGR	586 7.7 Ht	RT SGR
RR SCO	652 13.6 Pt	622 5.0 L	*191124*	589 7.8 Sm	*201139*
165030a		630 5.0 L	585[12.4 Bl	592 7.7 Bl	585 7.0 Bl
619 6.0 Dr		643 5.1 L		593 7.5 Ht	592 7.2 Bl

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J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.
RT SGR	R VUL	S MIC	RZ PEG	T TUC	V PHE
201139	205923a	*212030*	220133b	*223462*	*232746*
603 7.0 Bl	625 8.6 Pt	603 11.6 Bl	620 10.5 By	593 11.1 En	612 11.8 Ht
612 7.5 Bl	V CAP	612 10.9 Bl	621 10.5 By	609 10.4 Dr	615 11.7 Dr
WX CYG	*210124*	Y CAP	625 10.5 By	612 10.7 Ht	619 11.1 Dr
201437b	585[12.7 Bl	*212814*	625 10.0 Pt	615 10.1 Dr	623 10.7 Dr
609 10.5 Ch	625 13.7 Lg	586[12.9 Bl	628 10.7 By	619 10.3 Dr	641 9.6 Dw
624 11.1 L	641[13.5 Lg	592[12.9 Bl	T PEG	623 9.8 Dr	Z AND
625 10.8 Pt	X CAP	603[12.0 Bl	220412	640 8.8 Dw	232848
633 10.7 L	*210221*	W CYG	616 12.6 Ch	R LAC	616 9.2 Ch
U CYG	585[12.7 Bl	213244	617 12.6 L	223841	635 9.3 Bw
201647	X CEP	617 5.7 L	626 12.3 L	615 9.4 Ch	646 9.9 Bw
609 10.8 Ch	210382	624 5.6 L	633 11.8 L	624 9.5 L	659 9.2 Bw
625 11.0 Pt	626 9.3 L	633 5.7 L	Y PEG	625 9.0 Pt	ST AND
U MIC	640 9.2 L	S CEP	220613	633 9.0 L	233335
202240	RS AQR	213678	625 12.7 Pt	R PEG	616 11.5 Ch
585 12.7 Bl	*210504*	611 10.9 Ch	T GRU	230110	617 11.1 Lg
Z DEL	627 10.4 L	624 10.7 Ah	*221938*	615 12.9 Ch	624 11.3 B
202817	T CEP	625 9.6 Pt	582 9.2 Sm	624 13.5 Sf	625 11.0 Pt
625 10.0 Pt	210868	626 10.8 By	589 9.0 Sm	625 12.8 Pt	637 11.8 Lg
ST CYG	610 8.0 Ch	627 10.7 By	592 8.7 En	640 12.4 Lg	639 11.4 Al
202954	613 7.7 Ah	628 10.7 By	602 10.0 En	640 13.3 Sf	642 11.2 Wy
622[12.9 Wy	619 8.0 Ah	640 10.4 By	S GRU	V CAS	648 11.0 Al
625 13.7 Pt	619 7.5 Ch	641 10.7 Ah	*221948*	230759	R AQR
V VUL	621 7.9 Ah	642 10.8 Ah	582[12.8 En	613 8.0 Ah	*233815*
203226	622 8.1 Ah	643 10.5 By	589[12.8 Sm	616 7.8 Ch	582 9.0 En
625 8.5 Pt	624 8.1 Ah	646 9.5 Jo	592[12.8 En	619 8.4 Ah	582 9.2 Ht
R MIC	625 7.5 Pt	654 9.7 Jo	599[12.8 Ht	621 8.7 Ah	582 8.9 Bl
203429	628 8.2 Ah	RU CYG	609 13.1 Dr	622 8.8 Ah	583 9.2 Sm
585 9.4 Bl	631 8.1 Wd	213753	615 12.7 Dr	624 9.2 Ah	586 9.1 Ht
592 9.9 Bl	631 8.5 Sb	642 9.4 Wy	RV PEG	625 8.3 Pt	592 8.7 En
603 10.8 Bl	633 8.2 Ah	646 10.0 Bw	222129	626 9.2 B	592 9.0 Bl
S DEL	635 8.9 Sb	RV CYG	617 9.5 L	629 9.5 Ah	593 8.9 Ht
203816	639 7.7 Jo	213937	626 9.8 L	631 9.2 Kz	594 8.7 Sm
614 9.4 Lj	640 8.2 Ah	617 6.8 L	633 9.7 L	631 9.3 Eb	599 8.6 Ht
623 9.6 Lj	642 8.4 Ah	624 6.8 L	S LAC	633 9.6 Ah	603 8.9 Bl
625 9.7 Lj	646 9.4 Sb	625 6.2 Pt	222439	640 9.8 Ah	605 8.9 Ht
625 9.2 Pt	646 8.0 Jo	632 6.8 L	615 7.6 Ch	641 10.0 Ah	610 8.6 Ch
630 9.7 Lj	648 8.1 Al	RR PEG	623 8.3 An	643 10.1 Ah	612 9.0 Ht
V CYG	650 9.3 Sb	214024	624 7.9 L	W PEG	612 9.0 Bl
203847	654 9.4 Sb	625 14.0 Pt	625 7.9 Pt	231425	622 8.6 Lg
609 13.0 Ch	Y PAV	R GRU	633 8.4 L	613 11.5 Kl	623 8.5 Lg
616 13.1 Ch	*211570*	*214247*	R IND	616 12.4 Ch	623 9.2 An
625 13.4 Pt	551 6.7 Ht	582[12.4 En	*222867*	621 12.1 An	624 8.9 L
U CAP	568 6.5 Ht	586[13.7 Bl	582 8.6 Bl	627 12.5 Lg	625 8.5 Lg
204215	582 6.1 Ht	589[12.9 Sm	592 8.7 Bl	639 11.8 Al	629 8.8 Pt
586[13.1 Bl	586 5.8 Ht	592[12.4 En	603 9.3 Bl	641 12.2 Wy	637 8.3 Lg
T AQR	593 5.6 Ht	599[12.4 Ht	609 10.4 Dr	S PEG	639 8.6 Lg
204405	612 6.1 Ht	612[12.4 Ht	612 10.4 Bl	231508	639 9.2 Al
610 9.2 Ch	X PEG	615[13.4 Dr	615 10.7 Dr	625 13.0 Pt	640 8.7 Lg
RZ CYG	211614	U AQR	640 12.8 Dw	V PHE	641 8.5 Lg
204846	625 12.3 Pt	*215717*	641 13.0 Dw	*232746*	642 8.7 An
625 12.0 Pt	T CAP	617 11.6 L	T TUC	582 12.7 En	Z CAS
626 12.5 B	*211615*	RT PEG	*223462*	582 13.2 Ht	233956
S IND	585 12.5 Bl	215934	582 12.3 En	583 13.2 Sm	622 13.7 B
204054	S MIC	615 12.6 Ch	582 12.3 Ht	586 13.2 Ht	640[13.5 Lg
585[13.5 Bl	*212030*	626 11.3 B	582 12.3 Sm	592 12.4 En	RR CAS
R VUL	585 13.4 Bl	RZ PEG	586 12.3 Ht	593 12.8 Ht	235053
205923a	592 13.0 Bl	220133b	589 11.8 Sm	594 13.0 Sm	622 13.6 B
610 10.0 Ch		617 10.3 By	593 11.3 Ht	609 12.1 Dr	624[11.7 Bn

Variable Star Observations Received During February, 1929.

J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.	J.D.Est.Obs.
R Phe	R Tuc	R Cas	R Cas	Z Peg	Y Cas
235150	*235265*	235350	235350	235525	235855
615 13.8 Dw	582[12.9 Sm	621 8.0 Ah	631 8.3 Eb	625 12.4 Pt	624 11.5 L
615 13.6 Dr	593[12.9 En	622 8.0 Ah	631 8.0 Kz	W Peg	633 11.6 L
623 13.5 Dr	R Cas	622 7.6 B	633 8.5 Ah	*235715*	SV And
641 13.5 Dw	235350	624 8.2 Ah	640 8.9 Ah	622 9.4 Lg	235939
V Cet	616 7.5 Ch	628 8.4 Ah	641 9.0 Ah	Y Cas	624 13.4 B
235200	619 7.9 Ah	630 8.5 Ah	642 9.0 Ah	235855	625 13.1 Pt
586[13.6 Bl			643 9.0 Ah	622 10.4 B	641 13.3 Lg
					659[12.9 Bw

Rapidly Varying Irregular Variables.

Star J.D. Est.Obs	J.D. Est.Obs.	Star J.D. Est.Obs.	J.D. Est.Obs.
005840 RX Andromedae—		074922 U Geminorum—	
5626.5 11.1 Pt	5647.5[12.4 Pt	5618.1[13.8 Ch	5637.7[12.0 Lg
5638.6 10.9 Pt	5652.5 10.9 Pt	5619.7 13.7 L	5638.5[12.4 Wy
5640.6 11.0 Pt	5653.5 10.9 Pt	5621.4 13.8 L	5639.7 14.0 Lg
5644.6[12.4 Pt	5654.5 11.0 Pt	5621.8 13.8 Lg	5640.3 13.6 L
5646.6 12.0 Pt		5622.1 14.0 Ch	5640.8 13.2 Lg
010884 RU Cephei—		5622.8 13.8 Lg	5640.8 13.0 Lg
5632.3 8.8 L	5641.3 8.7 L	5623.6 13.8 L	5641.4 13.5 L
060547 SS Aurigae—		5623.8 13.9 Lg	5641.6 13.5 B
5602.1[13.3 Ch	5632.6 14.4 L	5624.6 13.9 L	5641.6 13.6 Lg
5606.2[11.6 Ch	5633.3 14.0 L	5625.6 14.1 L	5641.9 13.5 Lg
5609.1 12.0 Ch	5634.7[13.5 Lg	5625.8 13.8 Lg	5644.5 13.5 B
5612.1 13.8 Ch	5637.7 13.1 Lg	5626.6[13.7 B	5644.6[13.3 Pt
5613.2 14.0 L	5637.9 12.7 Lg	5627.4 13.6 L	5645.6[12.5 Cl
5613.6 14.2 L	5638.3 12.0 L	5628.1[13.7 Ch	5646.6[13.0 Cl
5615.1 13.7 Ch	5638.3 12.2 L	5629.6 13.7 L	5647.5[12.3 Pt
5615.2 13.0 L	5638.5 12.4 Wy	5630.4 13.7 L	5648.5 13.5 B
5615.7 12.5 L	5638.6 12.5 L	5630.7 14.0 L	5648.6 13.7 Gi
5616.1 12.0 Ch	5639.3 12.1 L	5631.4 13.9 L	5650.5 13.6 B
5617.2 12.0 L	5639.6 12.9 Lg	5631.7 14.1 L	5652.5[13.3 Pt
5617.6 12.5 L	5639.9 12.8 Lg	5632.6 14.0 L	5653.5[13.3 Pt
5618.1 12.0 Ch	5640.2 12.6 L	5633.4[13.7 L	5654.5[13.3 Pt
5619.1 12.8 Ch	5640.5 13.3 Sf	5634.8[13.0 Lg	
5619.6 13.5 L	5640.6 13.0 L	081473 Z Camelopardalis—	
5621.4 13.8 L	5640.6 13.5 Pt	5613.3 11.6 L	5627.4 11.0 L
5621.8 14.3 Lg	5640.6 13.0 Lg	5613.6 11.6 L	5628.3 11.2 L
5622.1 14.0 Ch	5640.9 13.1 Lg	5615.3 12.4 L	5629.6 11.6 L
5622.5 14.1 B	5641.2 13.7 L	5615.7 12.4 L	5630.3 11.5 L
5622.8 14.1 Lg	5641.6 13.3 Lg	5617.2 13.1 L	5630.6 11.4 L
5623.6 14.7 L	5641.9 13.5 Lg	5617.7 12.5 L	5631.4 11.9 L
5624.3 14.7 L	5642.5[13.3 Wy	5619.7 12.6 L	5631.7 11.7 L
5624.5 14.0 B	5644.6[13.5 Pt	5621.3 12.8 L	5632.3 11.9 L
5625.7[14.1 Lg	5645.6[12.5 Cl	5622.4 12.9 An	5632.6 11.8 L
5627.4 14.6 L	5646.5[12.5 Cl	5622.7 12.3 L	5633.3 11.8 L
5628.1 13.7 Ch	5647.5[12.6 Pt	5623.3 12.1 An	5633.6 11.5 L
5629.6[13.7 L	5652.5[13.5 Pt	5623.7 12.3 L	5638.2 11.5 L
5630.3 13.9 L	5653.7 13.5 Bw	5624.3 12.4 L	5638.7 11.5 L
5630.6 14.5 L	5654.5[13.0 Pt	5624.7 11.9 L	5639.2 11.5 L
5631.4 14.6 L	5655.6 13.5 Bw	5625.3 10.8 L	5640.6 11.4 L
5631.7 14.2 L	5659.7[13.3 Bw	5625.7 11.0 L	5641.2 11.8 L
5632.3 14.5 L		094512 X Leonis—	
074922 U Geminorum—		5613.6[14.2 L	5621.4 12.0 L
5602.1[13.3 Ch	5615.4 13.7 L	5615.4[13.9 L	5622.7 12.2 L
5606.2[11.4 Ch	5615.7 13.8 L	5615.6[13.9 L	5623.6 11.7 L
5612.2 14.0 Ch	5616.1[13.3 Ch	5617.4[13.5 L	5624.4 12.1 L
5613.4 13.7 L	5617.4 13.7 L	5617.7[12.3 L	5624.6 12.1 L
5615.1 14.0 Ch	5617.7 13.8 L	5619.6 12.0 L	5625.4 12.2 L

RAPIDLY VARYING IRREGULAR VARIABLES.

Star	J.D.	Est.Obs	J.D.	Est.Obs.	Star	J.D.	Est.Obs.	J.D.	Est.Obs.
094512 X LEONIS—					213843 SS CYGNI—				
	5625.6	12.6 L	5632.6	14.7 L		5622.7	11.1 Lg	5638.5	12.0 Wy
	5627.3	14.3 L	5633.4	12.5 L		5623.2	11.8 Lj	5639.5	12.0 Wy
	5627.6	14.7 L	5633.6	14.7 L		5623.2	11.9 An	5639.7	11.8 Lg
	5628.6	13.9 L	5638.6	11.8 L		5623.7	11.6 Lg	5640.2	12.2 L
	5629.6	14.2 L	5640.4	13.9 L		5624.2	11.9 Ah	5640.2	11.8 Lj
	5630.4	13.9 L	5640.6	13.9 L		5624.3	12.0 L	5640.5	11.9 Sf
	5630.6	14.2 L	5641.4	13.0 L		5624.5	11.8 Sf	5640.6	11.6 Lg
	5631.6	14.7 L	5643.7	12.3 L		5624.7	11.3 Lg	5640.6	11.6 Pt
	5632.3	12.3 L				5630.3	11.8 Lj	5641.2	12.2 L
202946 SZ CYGNI—						5625.3	12.1 L	5641.3	11.6 Ah
	5625.6	9.3 Pt	5646.6	9.4 Pt		5625.3	11.8 Kl	5641.6	11.8 Lg
	5627.5	8.8 Pt	5647.5	9.2 Pt		5625.6	11.6 Pt	5642.2	11.9 Lj
	5638.6	9.6 Pt	5652.5	9.6 Pt		5625.7	11.6 Lg	5642.3	11.7 Ah
	5640.6	9.2 Pt	5632.5	9.5 Pt		5626.2	12.1 L	5642.5	12.0 Wy
	5644.6	9.2 Pt	5654.9	9.5 Pt		5626.5	11.7 B	5642.5	12.0 Sf
	5645.6	9.1 Pt				5627.2	12.1 L	5643.2	11.9 Lj
213843 SS CYGNI—						5627.5	11.7 Pt	5643.3	11.8 Ah
	5602.1	11.5 Ch	5615.3	12.2 L		5628.3	12.1 L	5644.2	11.8 Kl
	5606.1	11.6 Ch	5616.0	11.8 Ch		5630.3	11.9 Lj	5644.6	11.7 Pt
	5607.1	11.6 Ch	5617.2	12.2 L		5630.5	12.2 L	5645.2	11.8 Kl
	5609.1	11.7 Ch	5619.2	11.8 Ah		5631.3	11.8 Lj	5645.6	11.7 Pt
	5612.1	11.9 Ch	5619.1	11.8 Ch		5631.5	11.8 Sf	5646.2	11.8 Kl
	5613.1	12.0 Ah	5620.3	11.8 Kl		5632.3	12.0 L	5646.6	11.7 Pt
	5613.3	11.8 Kl	5621.3	11.7 Ah		5632.5	11.8 Sf	5647.5	11.7 Pt
	5613.3	12.3 L	5621.4	12.1 L		5633.2	12.1 L	5648.5	11.2 Al
	5614.3	12.0 Lj	5622.1	11.7 Ch		5637.7	11.8 Lg	5649.2	11.3 Kl
	5615.1	12.2 Ch	5622.3	11.5 Ah		5638.2	12.2 L	5652.5	9.0 Pt
	5615.3	11.8 Kl	5622.5	11.6 B		5638.6	11.7 Pt	5653.5	9.0 Pt
						5638.5	12.0 Sf	5654.9	8.9 Pt

SUMMARY FOR MONTH ENDING FEBRUARY 28, 1929.

Observer	Initial	Vars.	Observations	Observer	Initial	Vars.	Observations
Ahnert	Ah	36	237	Guiler	Gi	7	11
Allen	Al	37	48	Houghton	Ht	31	65
Ancarani	An	20	37	Jones	Jo	19	46
Baldwin	Bl	76	188	Kohl	Kl	4	26
Beyer	By	8	48	Kurtz	Kz	15	15
Bigelow	Bw	19	33	Lacchini	L	117	433
Boutell	BL	3	26	Leiner	Lj	10	32
Bouton	B	76	89	Logan	Lg	46	116
Brown	Bn	3	5	Peltier	Pt	175	245
Chandra	Ch	76	129	Rowley	Rw	2	2
Clement	Cl	6	8	Smith, F.W.	Sf	20	49
Dartayet	Dr	56	188	Smith, W.H.	Sm	39	72
Dawson	Dw	12	16	Soberanes	Sb	9	25
Ebert	Eb	15	15	Waterfield	Wf	1	3
Ensor	En	42	79	Webb	Wd	9	9
Ford	Fd	8	8	Whitney	Wy	33	55
Gaebler	Gb	3	3	Wilson	Wn	6	7
				Totals		34	381	2370

Two of the well known SS Cygni variables have been "acting" recently, SS Cygni itself having been at maximum on February 12, seventy-five days after the previous maximum. SS Aurigae was observed at magnitude 13.5 for a few days at about the same time, indicating a possible abnormal minimum, and it was at normal maximum magnitude 11.0 on February 25. The expected rise of

U Geminorum has evidently not occurred, or if it has, it came at a time when clouds prevented its observation. A narrow maximum was due early in February. Several observers have noted the abnormally bright minimum of this variable during February.

Another contribution has arrived from Mr. Ford, this time from Pisa where he had the use of a 4-inch telescope.

An 8-inch reflector has been purchased by the Association for the use of some of our Italian observers. We are indebted to Mr. Lacchini for securing this fine instrument for our work. Incidentally Mr. Lacchini has sent to us one of the very best reports ever received; with many observations on some of the most important irregular variables. He reports most excellent observing conditions at Catania, Italy.

LEON CAMPBELL, Recording Secretary.

March 10, 1929.

METEOR NOTES.

By CHARLES P. OLIVIER.

The American Meteor Society has begun the year 1929 with excellent prospects. This is due not only to the considerable number of trained, active members who now have been connected with it for some years, but also to a recent, steady growth in membership. Some of these new members have wasted no time, but already have got down to work, sending in results which promise well for the future. The organization at headquarters has also been improved in a number of particulars, and better means have been developed for keeping in constant touch with our members. An increasing number of non-members, interested in science, send in casual observations, showing that the importance of the work of the A.M.S. is being more widely understood.

A fine report from R. A. McIntosh, of Auckland, New Zealand, from observations made on four nights in January, furnishes the following data. The first column in the table of radiants gives his own personal number for each radiant.

1929	N. Z. M. T. Began	Ended	Time	Meteors	Rate	Factor	Cor. Rate
	h m	h m	m				
Jan. 16	2 10 to	3 20	70	21	18.0	1.0	18.0
17	2 10	3 34	84	18	12.9	1.0	12.9
20	1 55	2 40	45	8	10.7	0.7	15.3
21	2 15	2 40	85	17	12.0	0.7	17.1

Radiants

No.	Date	α	δ	Meteors	Wt.	Notes
93	1929 Jan. 15.64	107.	—36.	5	F	4 on Jan. 15, 1 on Jan. 16
94	15.64	120.	—29.	7	G	
95	15.64	132.2	— 7.0	4	G	
96	15.64	134.	—57.	8	G	3 on Jan. 15, 5 on Jan. 16
97	16.64	177.7	—18.6	7	G	
98	19.62	162.1	—13.7	5	G	4 on Jan. 19, 1 on Jan. 20
99	20.64	132.5	—50.5	5	G	Compare No. 96
100	20.64	177.0	—11.0	5	F	
101	20.64	144.	—42.	4	P	1 on Jan. 15, 1 on Jan 16, and 2 on Jan. 20

Mr. R. C. Skinkfield of Adelaide, S. Australia, observed for the Geminids on 1928 December 10 from 9:40 to 10:40, seeing 3 sporadic meteors only, though the sky was clear; and on December 11 from 9:00 to 11:45, seeing no meteors whatever, the sky being mostly clear.

A delayed letter from Miss Leah B. Allen of Hood College, Frederick, Md., reports that she observed for Leonids on the nights of 1928 November 13 and 14. On the first date from 14:52 to 15:57, sky good, 7 meteors, of which 3 were Leonids, were seen. On second date, in partly cloudy sky, in half an hour between 14 and 16 hours, 4 sporadic meteors were seen. Also on 1928 October 19, from about 16 to 17 hours, she saw 15 Orionids.

Dr. Willard J. Fisher of Harvard College Observatory on 1929 January 2, sky clear, moon past last quarter, observed for the Quadrantids. His results follow:

1929 Jan. 2	16:00	to 16:30	4 Quadrantids,	2 doubtful
	16:30	17:00	8	1
	17:16	17:46	9	1
			21	4

One Quadrantid was seen later also, so this proves that they returned in good numbers on that date. One Quadrantid was >1 magn., one equal to Venus. Dr. Fisher sends with his report one, containing a chart, by Miss Margaret Olmsted, for the same night. She observed from 15:45 to 16:30 E.S.T., and plotted eight meteors, 7 being Quadrantids. Six of these 8 were of about first magnitude. As all the meteors are in a sector of about 30°, an accurate radiant cannot be obtained, though the paths are well determined.

Two of our new members, John C. Conboy of Lawton, Oklahoma, and Bert C. Darling of Lansing, Michigan, have made an excellent beginning. The first observed 9 nights from January 18 to February 27 inclusive, plotting 47 meteors. On each night he observed continuously for periods of from one to three hours. B. C. Darling, from February 19 to March 9 inclusive, observed 25 meteors. Continuous observations of long duration on March 7 and 9 yielded at least two radiants of interest. Details of the work of both of these observers will be published later.

We have the pleasure of welcoming as new members the following:

Alpha Nu Fraternity, Univ. of Colorado, 1061 14th St., Boulder, Colo.
Richard W. Aldrich, 626 E. Washington St., Hoopeston, Illinois.
Daniel Moreau Barringer, 1242 Real Estate Trust Bldg., Philadelphia, Pa.
Dr. Lewis C. Carson, Dept. Psychology, State Teachers College, Santa Barbara, California.
Bert C. Darling, 1809 Osborn Road, Lansing, Michigan.
Tom Davenport, B. S., 2121 S. Lincoln St., Denver, Colorado.
Dr. H. F. Donner, Lamont-Hussey Observatory, Bloemfontein, S. Africa.
W. E. Ormond, Wheat Swamp School, R. 5, La Grange, Georgia.

Of these the name of Mr. Barringer is already well known to everyone interested in meteoric astronomy, due to his splendid scientific work at Meteor Crater, Arizona. To his work, extending over a quarter of a century, we owe the definite proof of its impact origin. This should be the more carefully emphasized as at first scientific opinion, on the whole, was adverse to this theory, and several men of prominence pronounced judgment against it. Undeterred by this, Mr. Barringer never ceased his efforts in behalf of the impact theory until today it is universally accepted. Indirect attempts to give by inference this credit to an-

other, who, it can be proved, discarded this theory in favor of that of a steam explosion, as seems to have been done last year in a widely circulated magazine, call for this public statement on the part of the writer.

We regret to announce the death of Mr. N. P. Ball of California, who for several years was one of our most active members. Just after the World War, when our membership fell off and our prospects were at their lowest, his very extensive work was of particular value. The final results of this will appear in our publication M 4, now in press.

It is planned to issue a bulletin with a revised membership list, complete up to May 1, 1929. A circular letter has been sent to all recently inactive members, to which they are urged to reply at once so that their names may remain on the list of our members.

Flower Observatory, Upper Darby, Pennsylvania, 1929 March 19.

COMET NOTES.

By G. VAN BIESBROECK.

The only comet visible at this time in medium sized instruments is COMET 1929 *a* (SCHWASSMANN-WACHMANN). It is, however, a very inconspicuous object; its total brightness is of the order of a 12^M star (March 10). The nucleus is somewhat sharper than it was in January and the tail on the following side can still be seen over a length of two minutes of arc. We are near the time of perihelion and the brightness will soon fall off more rapidly.

The continuation of last month's ephemeris computed from Crommelin's elements (p. 175) is as follows (from *Copenhagen Circ.* Nr. 221):

EPHEMERIS OF COMET 1929 *a*.

1929 0^h U.T.	α h m s	δ ° ′
April 2	6 39 35	+23 15.0
6	46 36	14.2
10	6 53 51	11.6
14	7 1 17	7.3
18	8 54	23 1.1
22	16 40	22 53.0
26	24 34	43.0
30	32 35	31.1
May 4	40 41	17.2
8	48 51	22 1.4
12	7 57 5	+21 43.7

On March 10, the correction to the ephemeris was —9ˢ and —0′.5, showing that the elements are substantially correct. It will hardly be possible to follow the comet until the month of May. The continuation of the observations until the object is lost in the evening sky will define with greater precision the period of 6.4 years found so far, and thus help in locating the comet at its next return.

H. E. Wood (Johannesburg) has independently confirmed the periodicity of COMET FORBES (p. 112). He found a period of about 29 years, and thus established once more that between 1873 and 1928, as well as between 1818 and 1873 two revolutions have taken place. But the comet passed unnoticed in 1901. Wood's last elements are (*Journal of the Brit. Astr. Assoc.*, Vol. 39, p. 111):

Epoch Nov. 21.0 $M = 0° 33' 2''$
$\omega = 195\ 53\ 0$
$\Omega = 250\ 8\ 22$ } 1928.0
$i = 28\ 54\ 44$
$q = 0.74501$
$e = 0.92044$
Period = 28.65527 years

F. E. Seagrave sends the following ephemeris for this coming May deduced from these elements. After the rapid fading in December there is only the slightest chance of recording the object at such a late date:

EPHEMERIS OF COMET FORBES.

1929 0^h U.T.	α h m s	δ ° ′
May 1	12 44 42	−36 51.1
5	41 54	35 40.6
9	39 41	34 32.8
13	38 2	33 27.1
17	36 49	32 24.5
21	36 9	31 25.3
25	35 51	30 29.7
29	12 35 57	−29 37.9

The last position of the comet was obtained at Johannesburg on December 20, on which night the image was recorded on a plate exposed for 40 minutes. On December 24, the image was found on a similar exposure but it proved too faint for reliable measurement. The period of observation therefore covers only 35 days, the usable measures 29 days. This is in sharp contrast to the two other comets which are still under observation, though very faint, a long time after their discovery.

On March 10, COMET 1927 *d* (STEARNS) was found by the writer as a well-measurable image on an exposure of 25 minutes with the 24-inch reflector. This is the second year's anniversary of the discovery and there is a good chance of its being followed several months more. However, the total brightness is equivalent to a $15^M.5$ star. The ephemeris given on p. 57 requires only small corrections:

(O − C) March 10 in α −4s, in δ 0′.0.

COMET 1927 *i* (SCHWASSMANN-WACHMANN) is now too far in the western sky for further observations, but it can be safely predicted that next year its faint image will again be recorded near the computed position.

Attention should be called here to the computations by F. R. Cripps (*Handbook of the British Astr. Assoc.* for 1929), according to which we may expect

SEARCH EPHEMERIDES FOR PERIODIC COMET PERRINE.

1929 0^h U.T.	Perihelion July 20.0 h m	° ′	Perihelion July 28.0 h m	° ′
May 1	0 8.8	+12 19	23 55.3	+11 24
17	1 0.0	17 0	0 44.2	16 12
June 2	1 57.5	21 15	1 39.5	20 42
18	3 1.5	24 24	2 41.5	24 20
July 4	4 9.3	25 52	3 48.9	26 24
20	5 17.7	25 19	4 58.4	26 24
Aug. 5	6 22.4	22 53	6 5.4	24 22
21	7 20.6	19 3	7 6.2	20 41
Sept. 6	8 11.4	14 23	7 59.5	15 59
22	8 55.0	+ 9 24	8 45.1	+10 50

this summer a return of periodic comet Perrine 1896 VII. It has not been observed since 1909 although it has returned to the vicinity of the sun in 1916 and in 1922. After such a long interval the position is necessarily quite uncertain. The search ephemeris, of which we give here an abstract, is computed for two assumptions differing by 8 days, in regard to the time of perihelion, and indicates only in a general way where the comet is to be expected in the morning sky.

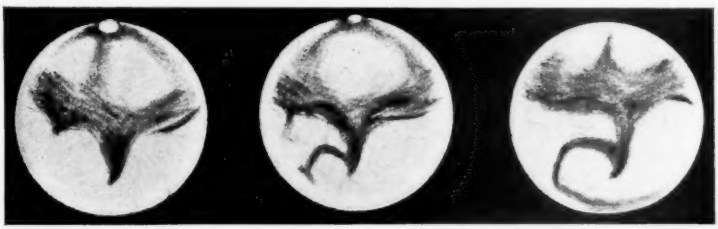
The distance from the earth remains large and the object will be faint. The most favorable conditions for the search are reached in the beginning of August, when the object rising about three hours before the sun will be at its brightest.

Williams Bay, Wisconsin, March 25, 1929.

NOTES FROM AMATEURS.

Changes On Mars.

Most amateur astronomers share with the general public the impression that it requires a large telescope to be able to make observations of the changes to be seen on the planets. However, I should like to give encouragement to these amateurs by showing that the moderate size, or even the small telescope, can give observations which are of value, and will show changes that can be seen in the surface markings, at least, of Jupiter and Mars.



1924 1926 1928

DRAWINGS OF MARS SHOWING CHANGES IN SYRTIS MAJOR REGION.

The drawings here shown of Mars were all made with a Clark telescope of only five inches aperture; and they show the changes on that planet during the oppositions of 1924, 1926, and 1928. When I started to make drawings of Mars in 1924, the South Polar Cap was very large, especially in July, although in the first drawing shown, made in October, it has decreased quite considerably. The Syrtis Major stands out quite distinctly and shows nothing of the Nepenthes marking in the second drawing. This marking was first seen by me on October 27, 1926, and was not visible on the previous evening. The South Polar Cap was much smaller in 1926 than it was in 1924; and it had practically disappeared towards the end of that opposition. In 1928 the South Polar Cap does not show at all; but we see in the third drawing that the Nepenthes marking has been extended in a huge semi-circle towards the North Pole. This marking, when seen reversed, in using a diagonal eye-piece, gives the perfect figure "5" extending nearly over the whole face of the of the planet when the Syrtis Major is at the center.

I found the best power to use on my telescope was 240. On clear nights I usually made six drawings one hour apart, and these showed the revolution of the planet during that period.

WILLIAM HENRY.

An Amateur's Telescope House.—I am enclosing some photographs of a telescope housing that may interest my fellow amateurs. It is inexpensive and far better than a dome. I know whereof I speak, for I have used both styles of housing. With the halves of the roof pushed clear back, the atmospheric currents so troublesome in small domes are avoided. The housing shown in Figure 1 cost approximately thirty-five dollars.

The telescope pier is composed of four cedar posts sunk into the ground and trussed and nailed together with wooden strips for rigidity. A coating of tar paint was applied to all posts before sinking them into the ground. A wooden platform carries the telescope—a home-made reflector of ten inches clear aperture. The telescope pier is separated from the floor of the house for steadiness in observing.

FIGURE 1.

Six cedar posts support the small nine by ten housing and its floor. The sides are of six-inch matched siding. It was framed of 2x4's and floored with four-inch matched flooring, laid on 2x6 joists. The door is of heavy beaver board on light framing. The roof is of canvas, stretched upon a light framework of one by three-inch pine. Other materials than canvas were experimented with but all were too heavy to handle when incorporated into a sliding roof, without expensive rollers. A half-round galvanized gutter hinged to one half closes the opening at the ridge when the roof is closed.

A first canvas cover was painted with oil and deteriorated in less than three years. Upon the old canvas a new covering of untreated material was spread which kept the housing perfectly dry for two years. The white canvas was swabbed with a mixture of lamp black and water to darken it. Rains have never whitened it.

Airplane "dope" would be an ideal finish for such a canvas roof, since it shrinks and tightens fabric as it dries. The canvas might be treated with the standard asphaltum roof paint of commerce.

Such a convenient housing adds greatly to the pleasures of using a telescope and tends to multiply the number of visits one pays the heavens with his instrument. Five minutes suffice to close and fasten the roof. Not so much time is required to open it. It tends also to preserve the silver films better than any form of wrapping, which requires almost as much time to take off and put on. Silver films now in excellent condition have been out summer and winter over two years in my reflector.

B. F. GILLMOR.

Red Oak, Iowa.

Aurora of March 11.—On the night of March 11, we witnessed a display of the aurora, which is rather infrequent in this locality. Some of the stars in the neighborhood of Polaris were under examination when the phenomenon was first noticed. This was at 10:55 P.M., E.S.T. The appearance was that of a considerable number of short, parallel lines of light, arranged much like a poorly defined spectrum, only without colors. The whole "spectrum" extended from a point just west of the Pole Star to a point in the NW, about midway between Capella and α Persei. The lights gradually changed in character, and appeared to travel toward the NW, until at 11:15 P.M. there were two long, slightly diverging streamers extending from the northwestern horizon upward for 45° or 50°. These streamers gradually became fainter, but the observations were not continued after 11:30 P.M.

The temperature at 11:30 was about 47° F, wind light from SW, seeing fair, but much steadier toward the south than toward the north.

HUGH G. and MARY M. BOUTELL.

3723 Jocelyn St., Washington, D. C.

Auroral Display.—On the evening of March 11, 1929, we observed at Swarthmore a very beautiful display of the Aurora Borealis. The writers and Professor Pitman of the Astronomy Department watched the phenomenon from the College athletic field, away from lights and obstructing trees.

The aurora was first generally noticed about 10:30 P.M. as a green, hazy patch around Cassiopeia. Soon streamers began to form which made certain the true nature of the appearance. They were between Cassiopeia and Polaris and consequently appeared slightly inclined to the west. The length of the streamers was from 2° to 8° and they were about 30′ wide. Their color was green, and this changed off and on to yellowish. The curious thing about them was that they steadily marched toward the west at the rate of about 1° to 2° per second. They would start almost directly north and move through about 45° of azimuth to the west. Their altitude was 30° to 40°. Their speed gradually slackened so that in about 15 minutes they no longer moved, and then they disappeared for a while. The main display gradually moved to the south, shooting beams occasionally almost to the zenith. It gradually approached the horizon, reaching it when the display reached the Pleiades. It finally stopped in a bright beam parallel to and 3° north of the line between Betelgeux and Bellatrix.

There was a long and bright display here with twisted and double beams, which were predominantly pale orange in color. This gradually faded and developed at 11:25 into a beam extending itself like a searchlight from the western

horizon to the eastern horizon in a comparatively faint arch of white light. This feature was peculiar, it having been seen by the writers at only one other display, that of June 1, 1926. Like the other streamers this one was *perpendicular* to the magnetic meridian, while the faint indefinite beam from which they sprang ran from Polaris to the Pleiades and was therefore *on* a magnetic meridian. At 11:30 the beam passed through ϵ Virginis, β Leonis, δ Cancri, λ Geminorum, and λ Orionis. It was about 2° wide and moved south at an irregular rate. At 12:00 it died out, having gone only a degree or two farther south than it was at 11:30.

During the whole display short, faint streamers appeared now and then just under Polaris. In the northeast there were only occasional traces of greenish rays at about 30° altitude. However, all along the north and northwest horizon there was a broad arch of bright green light with its greatest altitude about 15°. This arch showed traces of striation in a north to south direction. As the other display died out, this became brighter, and it was still bright at 1:00 A.M., at which time faint streamers filled the whole northern half of the sky.

It is remarkable that all the aurorae we have observed were on cool, calm, and clear but hazy nights.

At 11:15 P.M. we observed a bright meteor, the only one seen during the whole display. As many persons who were observing the aurora must have seen this meteor, it should be possible to compute accurately an orbit. Path, γ Geminorum to equator; $\angle$ to equator about +80°; magnitude 1; color, yellow; speed, slow; slight train; duration, 1 second; time, 11:15 P.M.

The next day (March 12) we observed an unusually large and complex sunspot. The appearance of the aurora was undoubtedly connected with this spot.

RAYMOND H. WILSON, JR.
JOHN W. EVANS, JR.
Swarthmore College, Swarthmore, Pennsylvania, March 16, 1929.

GENERAL NOTES.

Professor R. S. Dugan and Professor C. O. Lampland have interchanged places for the current semester, Professor Dugan being at Flagstaff and Professor Lampland, at Princeton.

Dr. Oswald Veblen, professor of mathematics at Princeton University, now lecturing at Oxford, recently received the degree of Doctor of Science from that University. (*Science*, March 8, 1929.)

Dr. C. G. Abbot, secretary of the Smithsonian Institution, gave an address on February 18 on the life and work of Spencer Fullerton Baird, the second secretary of the institution, at Dickinson College, Carlisle, Pennsylvania. (*Science*, March 8, 1929.)

Professor Frank Schlesinger, director of the Yale University Observatory, was awarded the Bruce Medal of the Astronomical Society of the Pacific for 1929, "for distinguished services to astronomy" and in particular for his work on photographic determinations of parallax and of star places. The Bruce Medal is awarded, usually every year, upon nomination by the directors of a number of large observatories in Europe and America.

Professor Henry Norris Russell addressed the monthly meeting of the Amateur Astronomers Association in the American Museum of Natural History, New York City, on March 20. His subject was "Analyzing the Sun."

Mr. Charles W. Elmer, on February 15, gave a lecture on Advanced Astronomy as part of a series given in the New York University. This course is for post-graduate students and is entitled "Fundamentals of Organic Science." At the close of the lecture, the questions asked by the students showed the lively interest that had been aroused.

Professor Henry Norris Russell, director of the Princeton University Observatory since 1912, has recently been promoted to the position of Research Professor in Astronomy at Princeton University. The endowment for this new chair is the part contributed by the class of 1897, of which Professor Russell is a member, toward a fund of $3,000,000 for research in pure science.

Dr. Alice Winbigler, for fifty years a teacher of mathematics in Monmouth College, Monmouth, Illinois, will retire from active duties at the close of the present academic year. Students of hers throughout these years have started a movement to endow the chair of mathematics in Monmouth College in her honor. It is planned to designate the coming commencement in June the Winbigler commencement.

Dr. W. H. Steavenson, one of the editors of the "Splendour of the Heavens," and an ex-president of the British Astronomical Association, is to visit various astronomical centers in this country during the month of May. Dr. Steavenson although not a professional astronomer nevertheless is an important and well-known person in astronomical circles in England. He will be the guest of Mr. David B. Pickering, president of the A.A.V.S.O.

Russell W. Porter, by common consent the leader of all the American amateur telescope makers and co-author of "Amateur Telescope Making," has been honored by a call to California by those who are in charge of plans for the new 200-inch telescope. The project is coöperative between California Institute of Technology and Mount Wilson Observatory. Mr. Porter will take part in the design of the instrument and optical shops required in connection with the new Astrophysical Observatory, and will also coöperate on the design of the great 200-inch telescope and other instruments. He retains his connection with Vermont, but he has also been designated Associate in Optics and Instrument Design at the California Institute of Technology. All amateurs will wish him success and follow his progress with keen interest. (A. G. I. in *Scientific American,* April, 1929.)

The Total Solar Eclipse of October 21, 1930. — Meteorological observations taken all last October in the morning, at Nivofov, show that the weather conditions for the total solar eclipse next year promise to be very favorable. Five days out of six during October gave a clear sky at eclipse time.

This island in the Tonga protectorate is the only land crossed by the belt of totality until it strikes the extreme southern coast of South America just before sunset. Information from the island shows that there should be no serious difficulty in landing heavy stores during September or October.

F. J. M. Stratton.

Amateur Astronomers Association Meeting.—At a recent meeting of the New York Amateur Astronomers Association held in the American Museum of Natural History, Mr. E. J. Gounod gave a lecture in which he suggested that the red color of Mars was really vegetation seen through the blue screen of our atmosphere. By experiments he has found that chlorophyll looks red when viewed through a blue screen.

Solar Research for Amateurs.—The first of a series of papers by Professor George Ellery Hale, on this topic, is published in the *Scientific American* for April. In it Professor Hale places a very high estimate upon the work of the amateur astronomer and points out further work for the amateur in studies of the sun. This series of papers will be found exceedingly interesting reading for any who have leanings toward the rapidly increasing body of astronomical literature.

Zodiacal Light Observations.

Since the beginning of the year cloudy, stormy weather has prevailed on evenings otherwise favorable for Zodiacal Light observations. Also on account of Venus being so conspicuously present in the western sky it has been extremely difficult to estimate the boundaries of the cone even when the planet has been screened off. Professor Leah B. Allen, Williams Observatory, Hood College, Frederick, Maryland, reports observations on February 2 and 3. At 8:30 P.M., February 3, she found the light extending along the horizon from α Pegasi to β Ceti, thence converging to the apex at η Piscium. Between 2:30 and 3:30 A.M., January 20, Professor Allen tried to discern the Gegenschein but could not delimit its boundary.

On February 11 at 7:45 P.M. the writer found the Zodiacal Light extending 25° along the horizon, the northern limit marked by a line drawn west from α Pegasi; the cone extended almost to the Pleiades. On the same evening he glimpsed the Gegenschein as an oval patch about 20° by 10° btween Praesepe and Regulus. On March 8, 10, and 11 he had satisfactory views of the Light at 7:45 each evening and found the apex of the cone passing through Aries and terminating just beyond the Pleiades which were immersed in the luminosity.

In the course of his observations of the Zodiacal Light during his service on the U. S. Japan Expedition (1853-55) Chaplain Jones, U.S.N., reported what he called the Moon Zodiacal Light. Concerning his observation on March 29, 1853, Lat. 2° N; Long. 104° 21′ E, moonrise, 10:10 P.M., he writes: "There is no doubt when the moon rises now its light is first shown at the bottom of the Zodiacal Light place. This evening at 9:50 there was a light on the ecliptic (eastern horizon) 52° in width, ascending 25° above the horizon. At 9:56 it extended 62° on the horizon and rose to a height of 32°. Then it rose quickly to 35° and so remained until the sky brightened rapidly as the moon rose."

The attention of observers is particularly called to this matter for possible corroboration of Chaplain Jones' report. A day or two before the moon's third quarter is best for this purpose.

W. E. Glanville.

The Rectory, New Market, Maryland.